NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

A SURVEY OF SOFTWARE FOR DECISION ANALYSIS

by

Craig L. Herrick

March, 1997

Thesis Advisor: Hemant Bhargava
Associate Advisor: Suresh Sridhar

Approved for public release; distribution is unlimited.

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	March 1997	Master's Thesis

4. TITLE AND SUBTITLE
A SURVEY OF SOFTWARE FOR DECISION ANALYSIS

5. FUNDING NUMBERS

6. AUTHOR(S) Herrick, Craig L.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Postgraduate School
Monterey CA 93943-5000

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(maximum 200 words)*

There are an increasing number of desktop decision support systems (DSS) generators available which can assist a manager in making decisions. The low cost of these packages also make them ideal instructional tools in academic courses covering decision analysis. Using literature review, surveys, correspondence and program inspection, this thesis demonstrates the features which are required of a good DSS as they relate to three potential uses: production, education, and demonstration.

This thesis discusses the characteristics a prospective user should consider when selecting a DSS. These characteristics include features such as the user interface, data and modeling support systems and the level of support available from the vendor. Following this, the thesis reviews the "state of the art" in currently available programs.

The programs reviewed in this thesis are easy to use and provide valuable tools for decision making. The programs lack in their ability to import and export data to other applications which limits their usefulness in a production setting, however, desktop DSS offer managers a sophisticated, yet easy to use, application which can improve decision making and benefit organizations at all levels.

14. SUBJECT TERMS	15. NUMBER OF PAGES
Decision Support Systems, Decision Analysis Tools, Computer Software	140
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18 298-102

Approved for public release; distribution is unlimited.

A SURVEY OF SOFTWARE FOR DECISION ANALYSYS

Craig L. Herrick
Lieutenant Commander, United States Navy
B.S., Old Dominion University, 1985

Submitted in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE IN INFORMATION TECHNOLOGY MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
March 1997

Author: _____
Craig L. Herrick

Approved by: _____
Hemant Bhargava, Thesis Advisor

_____
Suresh Sridhar, Associate Advisor

_____ for
Reuben T. Harris, Chairman
Department of Systems Management

ABSTRACT

There are an increasing number of desktop decision support systems (DSS) generators available which can assist a manager in making decisions. The low cost of these packages also make them ideal instructional tools in academic courses covering decision analysis. Using literature review, surveys, correspondence and program inspection, this thesis demonstrates the features which are required of a good DSS as they relate to three potential uses: production, education, and demonstration.

This thesis discusses the characteristics a prospective user should consider when selecting a DSS. These characteristics include features such as the user interface, data and modeling support systems and the level of support available from the vendor. Following this, the thesis reviews the "state of the art" in currently available programs.

The programs reviewed in this thesis are easy to use and provide valuable tools for decision making. The programs lack in their ability to import and export data to other applications which limits their usefulness in a production setting, however, desktop DSS offer managers a sophisticated, yet easy to use, application which can improve decision making and benefit organizations at all levels.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

I wish to thank Professors Bhargava and Sridhar for their guidance, wisdom, and patience while working on this project. They made it a valuable and enjoyable learning experience. Mr. David Hoffer, of TreeAge Software, and Mr. Ed Robins, of Arlington Software, provided valuable insight into how designers of DSS software saw the field. Both offered detailed answers to questions which were often open ended, as well as points of contact in the production arena.

I also wish to thank my wife, Susan, for her patience and support during the many hours of work required to prepare this thesis. Lastly, thanks to my parents, Captain Carl Herrick and Mrs. Anne Herrick for their encouraging me to pursue education and their support during my military career.

I. INTRODUCTION

Decision support systems (DSS) have been available for a number of years. Traditional systems were typically large mainframe applications developed for a specific purpose such as airline reservations or inventory control. In recent years, with the proliferation of desktop computers, a growing number of DSS generators have become available that enable the manager to easily tailor applications to specific and non-recurring decisions. Additionally, the low cost of some packages makes them ideal instructional tools in academic courses that teach decision analysis.

The objective of this research is two fold. This thesis will attempt to establish the features and characteristics a prospective user should consider when selecting a DSS generator. Since the appropriateness of a given DSS depends on its intended use, we will consider three potential uses: educational, production, and demonstration. In each of these environments different features of a DSS tool are desirable. A DSS used in a production setting would be more useful if it supports linkage with databases of various formats and sizes, whereas, a DSS used in the classroom would likely use only small demonstration data sets which can be constructed as needed. For demonstration use, power and flexibility may be less important than the ability to quickly build a working model. Certain features such as Windows and mouse interface, online help, and logical construction of decision problems are desirable in all DSS packages.

Second, having determined what features are desirable in a DSS, this thesis will review some of the most popular packages currently available detailing their specific advantages and shortcomings. Due to the rapidly evolving nature of computer software, this thesis will avoid specific recommendations for use of software packages, focusing instead on what issues the prospective user should consider when selecting a DSS.

Chapter II presents an *overview* of decision support systems, decision processes, and methods for decision making. Readers who are conversant with DSS can disregard this chapter. It is included as background material for those less familiar with DSS.

Chapter III discusses the *important features* which a prospective user should consider when selecting a DSS. Characteristics included features relating to the three components including the user interface, the database management system and the model management system. Desktop DSS generators are most capable in the user interface area, making effective use of the Windows and mouse interface of a PC. Most desktop systems lacked extensive database and model management features.

Chapter IV discusses considerations as they relate to *specific uses*. Different DSS features are more important to some users than others. In a production setting, DSS are perhaps more practical for non-recurring strategic decisions. The limited exchange capabilities of today's products make them less suited for recurring decisions which may rely on external data. DSS can make excellent supplements to classes which teach DSS. They can be used either to teach DSS or to demonstrate interactively the concepts of decision trees or multi-criteria decision making.

Chapter V highlights some of the more popular packages based on the considerations developed in Chapters III and IV. Chapter VI offers conclusions and recommendations for further research.

II. BACKGROUND: DECISION MAKING AND DSS

A. DECISION SUPPORT

Decision support is more than option selection. In practice, decision support consists of gathering information, prioritizing, filtering, the identification of decision options, the evaluation and implementation of options, and the evaluation of the decision process itself, which can occur before, during or after the decision making cycle. [Andriole, 1989]

Decision support systems are defined as interactive computer programs that utilize analytical methods, such as decision analysis, optimization algorithms, program scheduling routines, and so on, for developing models to help decision makers formulate alternatives, analyze their impacts, and interpret and select appropriate options for implementation. [Adelman, 1992]

In the1970's, decision support systems were written to support specific recurring problems and did not support reuse. These programs were typically custom designed for one application. In the1980's, DSS generators were introduced which allowed a user to custom tailor an application to a given decision. These programs typically lacked in various capabilities such as their user interface or data handling capabilities.

The decreasing cost of hardware and the increasing power of software in the1990's make it possible for decision makers to use sophisticated problem-solving techniques. Off-the-shelf DSS generators are much more affordable than they were just a few years ago. Many generators are now available for personal computers, thereby decreasing the implementation costs and problems. They make use of the user friendly Windows interface and offer increased data handling capabilities which make them more appealing to the typical manager with a limited management science background.

1. Benefits

There are clear commercial successes from the use of DDS. For example, a Canadian utility company uses a desktop DSS to determine when to deploy repair crews during

minimally staffed periods. A southwestern power company used a desktop DSS to select among various options for increasing power generation capability.

Improved organizational effectiveness can occur in many ways, such as through decreased personnel costs, greater access to expert knowledge, or improved decision making [Adelman, 1992]. Perhaps the greatest benefit of using a desktop DSS is not having a software package to solve the problem at hand but forcing the decision maker to define alternatives and work through a decision logically. Decision analysis is the discipline of evaluating complex alternatives in terms of values (what we care about) and uncertainty (what we know and do not know). Experienced decision analysts and educators stress that the benefits of decision analysis are insight into how the defined alternatives differ from one another, and generating suggestions for new and improved alternatives. Too many critics stress the use of numbers to quantify subjective values and uncertainties without realizing the power of quantitative analysis for generating qualitative insight [Booed, 1996].

2. Limitations

In spite of the successes, the "state of the art" has not matched the "state of the expectation." The fact is that many decision support systems are simply not used. Vendors have vested interests in overselling, and users are inclined to want to believe that a solution to all their problems can be found on one or two floppy disks. Andriole [p. 7] points out, that the state of the art of decision support systems technology is unbalanced and evolving [Andriole, 1989].

Managers do not use models as much as they could. Models require accurate data that may be time consuming and costly to produce. Even if a good model is developed and accurate data obtained, a manager may not understand it, preferring their own simple analysis to a complicated model. Lastly, even when managers do use a model and implement the results, they may not realize that this is what they have done.

In order to utilize such supporting software effectively, the user needs some understanding of the fundamental concepts of models and of decision support concepts. The

existence of user friendly modeling makes it easy to create bad models or to misuse good models [Young, 1989].

B. DECISION MAKING

Decision making is a basic skill required in any managerial position. It is only in the last 25 years, however, that management theorists have focused on decision making as a science. This section gives an overview of decision making, the importance of the environment in which the decision is being made, several strategies for making decisions, and the decision making process.

1. Decision Environment

There are a number of ways to view the environment in which a decision is made. Of primary importance in establishing environmental considerations is at what level in the organization the decision is being made. Figure 1 shows the three principle levels of decision making, strategic, tactical and operational.

Figure 1 Levels of decision making

At the strategic decision making level, top executives develop overall organizational goals, strategies, policies, and objectives through long-range strategic planning. They also monitor the strategic performance of the organization and its overall direction. At the tactical level, middle level managers develop short and medium range plans and budgets, and specify the policies, procedures, and objectives for units of the organization.

They also acquire and allocate resources and monitor the performance of organizational units. At the operational level, supervisory managers develop short range planning devices such as production schedules. They direct the use of resources and the performance of tasks according to established procedures and within budgets established for them.

The level at which the decision is being made typically dictates the environmental factors which influence decision making. These factors include the *type of stimuli*, *the degree of coordination*, the *nature of the task*, and the *degree of uncertainty*.

The *type of stimuli* refers to why the decision is being made. At a higher level, the stimulus is more controlled and may involve taking advantage of an unforeseen opportunity. At the lower level, decisions are more focused on solving urgent problems such as allocating personnel and resources.

The requirement for *coordination* increases at higher levels in the organization. At the lower levels of an organization, decisions tend to be more individual such as a unit supervisor planning the allocation of resources for a short time frame. At a higher level, executives may make group decisions using data pulled from many sources both inside and outside the organization.

Uncertainty in decision making also increases as the organizational level increases. This is only logical. At the lower levels of an organization, decision makers face somewhat routine decisions using limited amounts of data. At strategic levels executives are faced with decisions which they have never made before and with data pulled from multiple internal and external sources.

Nature of task refers to whether the task is unstructured, semi-structured, or structured. Structured decisions involve situations where the procedures to follow when a decision is needed can be specified in advance. Therefore, such decisions are structured or programmed by the decision rules developed for them. A structured decision may involve what is known as a deterministic or algorithmic decision. In this case, a decision's outcome can be determined with certainty if a specified sequence of activities (an algorithm) is performed. An example of such a system is the Navy's Uniform Inventory Control

Point (UICP) system which runs at the Navy Inventory Control Point. This system receives a requisition for material from a Navy unit, and then passes the requisition to a supply point for material issue based on such factors as the on-hand balance of the item at the various supply points. The rules regarding filling outstanding requisitions are programmed into UICP's B01 module and will result in a predictable decision being made for a set group of inputs.

Unstructured decisions involve decision situations where it is not possible or desirable to specify in advance most of the decision procedures that will follow. Many decision situations in the real world are unstructured because they are subject to too many random or changeable events or involve too many unknown factors. At most, many decision situations are semi-structured. Decisions involved in starting a new repair line at a Naval Aviation Depot, for example, would range from unstructured to semi-structured. The many unknown factors involved would require a less structured approach leading to subjective judgements by managers. Information systems can support such decisions by providing the ability to make ad hoc inquiries for information in databases and the ability to reach a decision in an interactive process using a DSS.

Decisions are also broken down between nonrecurring decisions, also called ad hoc, and recurring, also called institutional. The type of decision being made dictates many of the features which are required of the DSS as shown in Table 1.

Ad hoc vs. Institutional use:		
	Institutional	**Ad Hoc**
Decision occurrences for a decision type	Many	Few
Decision types	Few	Many
Number of people making decisions of same type	Many	Few
Range of decisions supported	Narrow	Wide
Range of users supported	Narrow	Wide
Specific data known in advance	Usually	Rarely
Problems recurring	Usually	Rarely
Importance of operational efficiency	High	Low
Duration of specific type of problem being addressed	Long	Short
Need for rapid development	Low	High

Table 1 [From Sprauge, 1996]

2. Decision Strategies

There are several avenues of approach that a decision maker can utilize in order to reach a decision. Different people will use different strategies at different times for different kinds of decisions. Which strategy to select depends on factors such as what is the information processing requirements for each decision making strategy and which strategy the decision maker prefers. Several strategies will be discussed including optimizing, satisficing, and selection by elimination.

a. Optimizing

The goal when optimizing is to select the course of action with the highest payoff. Using this technique requires the decision maker to estimate all costs and benefits of every viable course of action. In even a simple decision making scenario, optimizing can be an overwhelming task. In many cases, there is too much information to process and too many variables to consider simultaneously. This can result in a high cost in time, effort and money. Additionally, optimization of stated objectives may result in sub-optimization on unstated, less tangible objectives. As a result of the difficulty with the optimization technique, decision makers frequently do not consider all possible alternatives, do not consider all objectives and criteria or place more weight on intangible objectives.

Many desktop DSS generators perform "comparative optimization". The user declares the alternatives, and the programs helps the user compare them. Standard optimization tools (for linear programming) generate the alternatives from an abstract description of the constraints and test them.

b. Satisficing

Due to the complexities inherent in optimizing, decision makers often satisfice. They choose courses of action that are "good enough" that meet a certain minimal set of requirements. Multiple criteria are often used, but the "satisfactoriness" of an outcome is the decisive factor. Often, uncertainty about the best choice makes decision makers gravitate towards a more conventional second best choice.

c. Quasi-Satisficing

Quasi-satisficing is usually used in cases of crisis management or when the decision involves someone else's problem. It is applicable when there are fewer objectives that need to be met or when very few alternatives are generated. Quasi-satisficing can be summarized as "do something useful without deliberating about all other alternatives," or "do what we did the last time if it worked, or the opposite of if it did not."

d. Selection by Elimination

Selection by elimination involves eliminating alternatives that do not meet the most important criterion. Decision making using this strategy becomes a sequential narrowing down process. The disadvantage of this technique is that if improper weights are assigned to criteria, a "better" alternative might be eliminated early on. In addition, for more complex problems, this process might still leave the decision maker with a large number of alternatives.

3. Decision Process

The decision making process is generally considered to consist of three phases: intelligence, design, and choice. Intelligence involves the identification of a problem that requires a decision. Design involves the creation and evaluation of alternative courses of action. Choice is the selection of a course of action.

DSS typically addresses a specific problem that has been identified. Thus, it is often unnecessary to support the *intelligence* phase, especially for decisions at a lower levels.

The ability to support the *design phase* of decision making is the true test of DSS. The core of any DSS is the model base which has been built to analyze a problem or decision. The primary value to a decision maker of a DSS is the ability of the decision maker and the DSS to explore the models interactively as a means to identify and evaluate alternative courses of actions. This is of tremendous value to the decision maker and represents the DSS capability to support the design phase. [Sprague, 1996]

The *choice phase* of decision making is the most variable in terms of support from DSS. Although a custom designed DSS can be programmed to make decisions, DSS generators do not make decisions y them selves. They do however, present the user with a detailed analysis of the factors influencing the decision. In this regard they support the choice phase.

C. RELATED TECHNOLOGIES

There are a number of other types of programs that are similar to decision support systems and which are commonly grouped with DSS when teaching decision support or thinking about decision making. These programs include executive information systems, expert systems, and group DSS.

1. Executive Information Systems

Executive Information systems (EIS) typically are used to obtain and provide top managers with status information from various internal and external sources. Information

is presented in a wide variety of forms (textual, graphical, tabular) often on the same screen. An example of such a system was developed by Sherwin Williams Company. Their system, developed over the course of two years, was designed to replace a paper reporting system which ran from individual stores, through the regional management to the corporate headquarters. The new system uses a graphical interface and allows managers at all levels to review sales data of units under their control. [Booker, 1993]

2. Group DSS

One of the most popular forms of decision support systems being developed today is the Group DSS (GDSS). Group DSS focus on group activities such as discussions and meeting. The systems are designed to provide computer support for groups of people who work on collaborative projects. GDSS can play an important role in today's changing management environment. They can keep people in better touch with each other, support broader spans of control, and directly connect members of different organizations. GDSS includes a wide variety of products and are also called groupware, collaborative work support systems. [Sprague, 1996]

3. Expert Systems

Expert systems employ heuristics and qualitative reasoning to simulate the behavior of an expert, based on knowledge accumulated by experts. An example of an Expert System would be a program to help a medical professional diagnose an injured patient or to help a technician trouble shoot a piece of equipment.

4. Software

There are a number of software packages available which executive information systems, group DSS, expert systems, as well as forecasting. EIS are available from a number of companies. Comshare from Commander EIS or Pilot from Command Center allow users to develop custom EIS designed to take advantage of unique concerns of management. Group DSS are available from numerous vendors including Team Expert

Choice by Expert Choice and GroupSystems developed by the University of Arizona. Like EIS, Expert systems are frequently custom designed for a specific organization. Development tools include programs such as VP Expert, SuperExpert, and KnowledgePro as well as programming languages such as C++. Forecasting programs are available including such titles as: Minitab Statistical Software by Minitab Inc., SAS Software from SAS Institute Inc., Statgraphics Plus for Windows by Statistical Graphics Corp., and SPSS 7.5 for Windows by SPSS Inc.

Reviews of these types of program can be found in various information technology related journals including OR/MS, Datamation, and others.

D. SUMMARY

This chapter has given a brief overview of decision support systems, their benefits and their limitations. Traditional DSS differs from DSS generators in that the later can be easily tailored to specific situations. Appendix A provides additional information on various methods of decision analysis including decision making under uncertainty and decision making with multiple criteria. Readers unfamiliar with these techniques should review this appendix prior to proceeding to the next chapter.

III. DESCISION SUPPORT SYSTEM FEATURES

A. INTRODUCTION

When evaluating decision support systems, it is important to remember the obvious, which is that the overall aim of these systems is to improve the effectiveness of the organization using them. The first requirement to fulfilling this aim is to determine the correct type of package for the users need. After a review of the methodology used for this thesis, this chapter discusses some of the important characteristics on DSS generators may differ. Issues include such things as the technical considerations and the components of a DSS. Chapter IV discusses issues tailored to different categories of users.

B. METHODOLOGY

To determine which features are important in DSS selection the research for this thesis involved a review of current literature on DSS. Material was drawn from texts, magazines, journals and the World Wide Web. Most texts and papers written about DSS have similar recommendations regarding writing or selecting DSS packages.

In order to classify features important to the three categories of DSS users, an informal brainstorming session was undertaken to group, classify, and further develop the items on the list developed from literature review. From this list, we developed a survey which was sent to over 100 educators and professionals, as well as to DSS software companies. A separate survey was developed for production users, educational users, and vendors. Names were drawn from the online database of the Institute for Operations Research and Management Science (INFORMS) and from a search of the World Wide Web. Responses were received from 35 percent of those surveyed. The aim of the survey was to validate and refine the list obtained through brainstorming and to gain insight into other features DSS users felt were important. The surveys asked users to assign weights to the features of DSS, assigning a higher score to features they felt were most important. Additional dialog was held with DSS vendors and some users to explore questions raised by the survey. Detailed, anonymous responses to the survey are shown in Appendices F, G,

and H. Appendix I provides comparison between the average scores on the detailed surveys.

The survey consisted of seven questions. The first two questions were designed to gather background data. Educators were asked about the level at which they taught DSS and the role of DSS software in their class. Designers were asked about the number of copies of DSS software the company had produced. All users, production and educational, were asked about packages used, or rejected for use, and the reasons for doing so. Designers were also asked who they saw as their primary customers and how they best saw DSS software being used for strategic or operational use.

Question three regarded *criteria* to be considered when selecting DSS software. Survey recipients were asked to allocate 100 points between five criteria including the importance of the length of time required to learn to use the software, the ease of use, the availability of versions of the software to operate on multiple platforms, the ability to use the software in a network environment, and the cost of acquiring the software.

Question four asked questions related to *application features*. Again, survey recipients were asked to allocate 100 points among ten criteria including divided among features of the user interface, the data handling system, and the model system.

Question five asked recipients to rate the importance of criteria related to *training* users to use the program. Recipients were asked to allocate 100 points between the importance of sample exercises, online tutorials, explanations of results, and tips and insights.

Question six asked recipients to rank the importance *of specific DSS considerations* included in a software package, including the ability to modeling uncertainty, to handle subjective data, to work with utility functions, and to measure risk and sensitivity.

Lastly, *question seven* asked the users' questions related to *support issues* including the availability of FAQ files, discussion groups, mail lists, technical support via phone or email, local support, and documentation.

C. GENERAL DSS CONSIDERATIONS

This section discusses the general considerations for selecting a DSS. Criteria include what type of decision the user is trying to solve, what aspects of modeling a particular product addresses, and the technical requirements of the system.

1. Problem Type

What DSS problems does the product address? There is no one DSS package that is well suited to all decision problems. Broadly, the DSS packages reviewed for this thesis can be grouped into two areas, decision making under uncertainty and decision making for multi-criteria problems. Decisions involving uncertainty are typically solved using influence diagrams and decision trees. Decisions with multiple criteria are solved using the analytical hierarchy process. It is the responsibility of the potential user of these packages to determine which approach is most appropriate. A third category of programs that we reviewed, the spreadsheet add-in, does not fit into these two traditional areas. Though not technically a DSS, these packages are very useful tools for the decision maker.

2. What Aspect of DSS Modeling Does the Product Address?

In spite of the differences between applications, it is possible to identify certain common aspects of DSS modeling projects. Most attempts to use DSS software involve, for example, defining model components such as decision variables, objectives and constraints; gathering data required by the model; solving model instances; reporting and analyzing results; managing multiple model versions and data scenarios.

Independent of the specific software package being used, in order to create a decision analysis model, it is necessary to create the model structure and obtain the data to populate the model for computation. In some instances, trained analysts provide the model structuring support, however, the ease of use of these packages allows anyone to easily build relationships models. Some DSS start with an easy to use brainstorming feature and then progress to a decision support model.

Once the structure and numbers are in place, the analysis can begin. Much more is involved than computing the expected, weighted utility of each alternative. If the process stopped there, decision makers would not gain much insight into the problem being solved. Decision makers must examine the sensitivity of the key criteria and weights and risk preference parameters. As part of the sensitivity analysis, it is possible to calculate the value of perfect information for uncertainties that have been explicitly modeled. [Booed, 1996]. The more sophisticated DSS should allow the user to perform various forms of sensitivity analysis and to investigate decisions in depth.

The packages reviewed for this thesis are the stand-alone modeling systems, which are intended to provide the entire interface to the formulation, solution, and analysis stages of modeling. Some of the models allow import and export of data but they lend themselves only with difficulty to automated processes such as one that may be written with Delphi or Visual Basic.

3. Technical Considerations

The technical considerations involved in selecting a DSS are fairly straight forward and will only be discussed briefly.

•Operating systems, memory requirements, and printer support -- In most instances, the choice of operating systems and the memory required for a desktop DSS is dictated by a system that is already in place. Chapter IV discusses specific requirements of desktop systems. Appendix B lists requirements for currently available packages.

•Security -- Users should consider the sensitivity of the data that they are working with, especially if the program is being used in a network environment. Additionally, integrity may become an issue if more than one person is working on the model or the database.

•Group versus individual -- Many DSS which are being introduced today are designed to support group interaction. These packages contain voting tools and features which allow multiple people to combine their input on decision making. This thesis con-

centrates on packages designed for individual use. Where group features are present, they are noted.

•Process automation support -- More sophisticated users may require the ability to link the decision making abilities of a DSS to the analytical capabilities of a spreadsheet or to a database. A few users surveyed discussed the desire to be able to use Object Linking and Embedding (OLE) to control a decision process.

D. DSS COMPONENTS

DSS technology consists of three sets of capabilities, the User Interface Management System (UIMS), the Data Base Management System (DBMS) and the Model Management System (MMS). Figure 2 is a depiction of the relationship. The UIMS, also called the Dialog Generation Management System (DGMS) manages the interface between the user and the rest of the system. The DBMS and the MMS contain the necessary functions to manage the data base and model base, respectively. The characteristics of each section are discussed in greater detail later in this chapter.

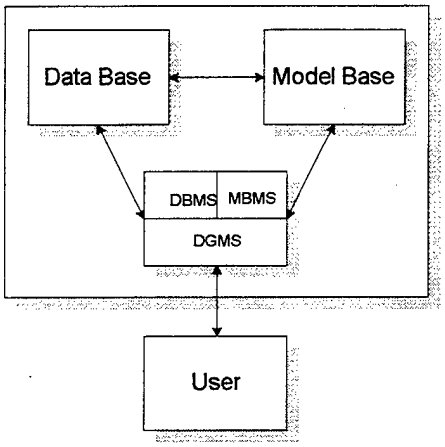

Figure 2 The components of DSS.

A good DSS should have balance among the three capabilities. It should be easy to use to allow non-technical decision makers to interact with the system, it should have access to a wide variety of data, and it should provide analysis and modeling in a variety of

ways. [Sprague, 1996] Unlike the early DSS generators which lacked in one or more of these areas, the current desktop systems offer a reasonable balance between these three components.

1. User Interface Management System

To a large extent, to the user, the User Interface Management System is the DSS. The sense of the general character of the software, but not the detailed operational structure, is obtained through interaction with UIMS. The power and scope of DSS functionality can only benefit a user if it is accessible and comprehensible. Ease of use and understanding are determined largely by the character of the interface. Similarly, the more a DSS can do, the more difficult it is to provide an interface that is easy to use and understand.[Young, 1989] The UIMS is characterized by the control mechanisms of the program, the quality of the display, and the dialog which is held between the system and the user.

a. Control Mechanisms

(1) Mouse and Windows Support -- Respondents to the thesis survey placed strong emphasis on the necessity of having mouse and Windows support for DSS packages. The graphical abilities of Windows make available a number of useful features such as dynamic sensitivity analysis which will be discussed later. Though most programs written today utilize the Windows interface, some provide more flexibility than others. For example, only a few programs make use of the right mouse button which opens a pop up menu showing the most appropriate features depending on where the mouse is pointing. This can be a time saving feature for the experienced user.

(2) Visualization and Ingredients of a Good Display -- Proper display design is critical. A number of studies have shown that tasks involving visual search, counting, noting of display changes and information extraction are adversely affected by a high numbers of items displayed on a screen. The more information displayed on a screen,

the greater the chances for error, misperception, frustration and eventual abandonment of the system. Ingredients to look for when evaluating a good display include:

- Orderly, clean, clutter free displays.
- Obvious indication of what is being shown.
- Expected information where it should be.
- Clear indication of what relates to what.
- Plain simple English.
- Clear indication when an action could make a permanent change in the data or model design [Andriole, 1989].

Many users find color input and output routines initially pleasing, however, research suggests that unless color is used carefully, its initial appeal will shortly be replaced with frustration. Many color displays violate some basic rules of presentation. First, too many colors often appear. Some use color inconsistently. Some use offensive combinations. One often wonders if the authors of software use color to improve performance or use it simply because color display devices have dropped in price. Figure 4 shows a display which violates most of the rules for appropriate guidelines for the use of color. Some considerations users should look for when evaluating the quality of a color display include:

- Use color as a formatting aid to relate or tie fields into groupings, emphasize important fields and relate fields that are spatially separated.
- Use color as a visual code to identify kinds of data, sources of data, status of data.
- For emphasis and separations use contrasting colors such as red and green.
- To convey similarity use similar colors such as orange and yellow.
- Use colors consistently within and across systems.

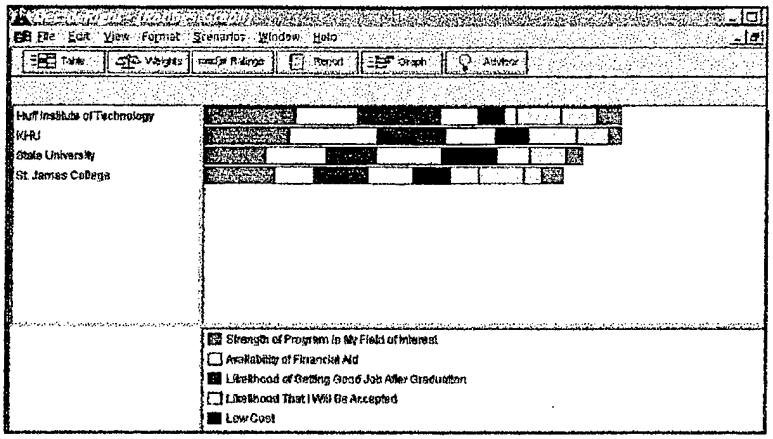

Figure 3 This output uses color for the sake of color. There is no meaning behind the colors selected in the output. [From Decide Right by Avantos]

The improper use of color will undermine the human-computer communication. [Andriole, 1989]

(3) Dialog management -- Over the years a number of different dialogues have been used for DSS. Dialog types include menues, query language, function keys and form filling. These dialog types vary in the complexity they involve as well as the flexibility they provide.

Menus are frequently used for command construction as well as data-base search. Pull down or pop up menus are frequently used to drive Windows based programs such as the ones review for this thesis. *Query Language* is frequently found in older programs. In this type of program, the user enters questions or data base access requests and the system produces a report. This is acceptable for a well-trained user, otherwise it can be error prone and frustrating. Query language is also used to access the help features of many Windows based programs allowing the user to enter the topic on which help is desired. *Function Keys* provide a short cut to frequently used commands and are found in some of the desktop DSS tools. Function keys provide flexibility for more experienced users of a program. *Form filling* presents a form with fill-in blanks which the user files in. This type of dialog is frequently used to enter data or weightings.

Dialog involves complexity versus flexibility trade-offs. For example, while the question-answer approach to data entry is simple and often appropriate for a novice user performing well structured tasks, it does not provide flexibility beyond what was planned by the systems designers. Menu oriented systems impose the same kind of structure. In contrast, command languages place the user more in control but require additional knowledge to use the systems. [Sprague, 1996]

Flexibility is a measure of the number of ways in which a user can accomplish a given function and can be achieved by providing a large number of commands. There is evidence that less experienced users tend to utilize known methods for solving a problem even when the system provides less cumbersome methods. There is also evidence that more flexible dialogues degrade performance of relatively inexperienced users.

Complexity is a measure of the number of options available to the user at a given point in the dialogue. Low complexity can be achieved by using few commands or by partitioning the commands so the user selects from a small set at any given time. [Andriole, 1989]

Most Windows based programs, including DSS generators, offer some degree of flexibility. A particular task may be performed in a number of ways such as with a pull down menu, a pop up menu brought up by double clicking an item, with a control key sequence or function key. This allows the user to perform a task in the manner in which they are most comfortable.

b. Input Representation

How are DSS problems expressed? The simplest way to describe a DSS problem to a computer system is to input a separate and explicit description for each individual variable or constraint (or both). Depending on the decision problem, various types of input data may be available including absolute or relative data.

In some instances, the user may have absolute data derived from experiment and testing. In selecting a new fighter aircraft, the prospective buyer would have ex-

plicit knowledge in advance regarding the speed of the competing aircraft and the utility derived from various speeds.

Programs which accept absolute data take the data in a variety of forms including: explicit data (e.g. mach 1.4) or as statistical values. The decision tree programs and a few of the hierarchy base programs accept data in this manner. Where explicit data values are entered in hierarchical programs, the user also has the opportunity to enter utility values for the various data points. Many of the programs will allow the user to enter statistical data in place of actual numbers. This is useful when using experimental data and results in output which represents a range of likely outcomes.

In contrast, in selecting a new car, the buyer would not have an explicit measurement of his preference for one car's style over another. He would probably know that he thinks that one vehicle is attractive while the other isn't or he may know that he prefers one design over another. In this case he has relative data; he knows the relative preference of one item over another, even though no specific scores can be assigned. Programs which use relative data, require the user to choose a preference of one item over another. This may be done by using a slide bar, by manipulating icons, or by entering numerical preferences. This type of data entry may be most useful when the user wants to make a quick decision without taking the time to gather detailed data.

c. Output Representation

How are results viewed and analyzed? DSS packages produce a variety of outputs which are useful in decision analysis. All programs present their recommendations in a graphical format while some also produce tabular data. Graphic displays are frequently much better communicators of information than alphanumeric.

All of the multi-criteria based programs produced a variety of bar charts showing the overall utility of the different output variables. Figure 4 shows a stacked bar chart which provides details concerning which variables contributed most to the recommendation.

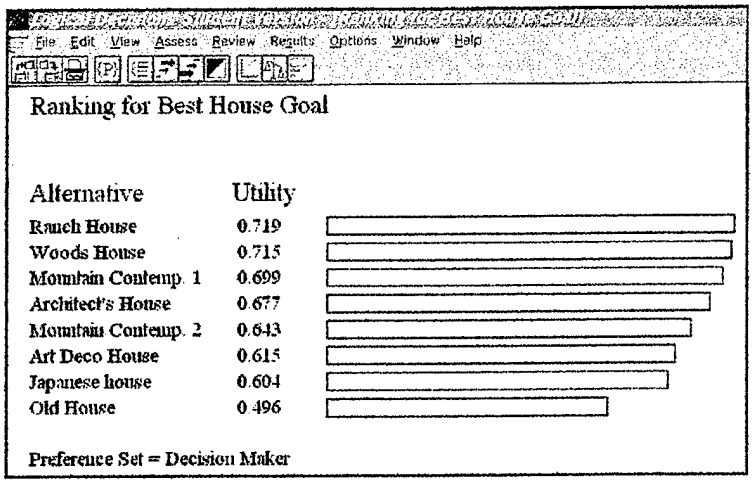

Figure 4 Multi-criteria programs generate a bar chart allowing the user to evaluate the contribution from various input variables. [From LDW by Logical Decisions]

A few programs will produce a greater variety of outputs. Figure 5 shows a scatter diagram which allows a quick comparison between two input variables.

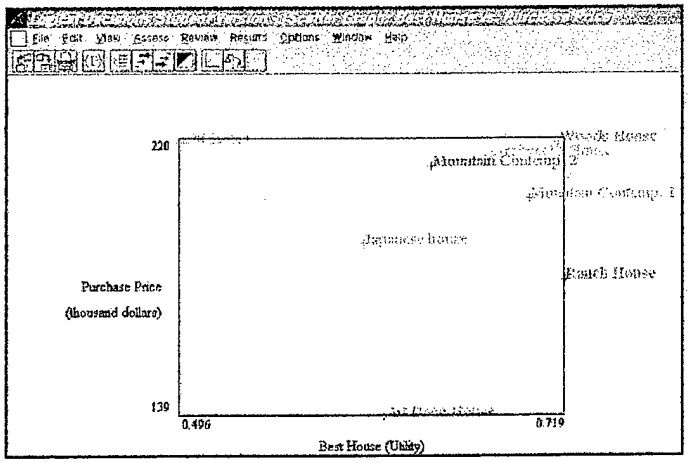

Figure 5 A scatter diagram compares two variables graphically. [From LDW by Logical Decisions]

Programs which perform decision making under uncertainty typically produce a probability distribution chart as shown in Figure 6. This allows the decision maker to determine the likelihood of the various outcomes.

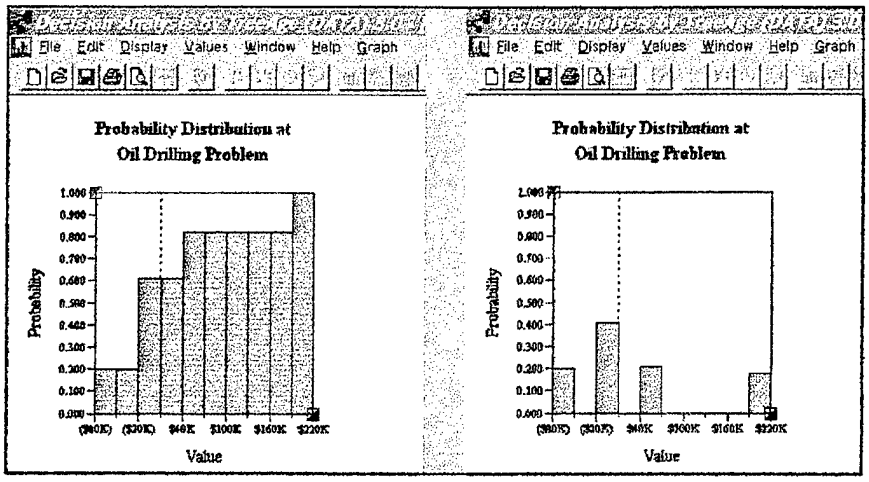

Figure 6 Programs using decision making under uncertainty produce probability distribution charts. The chart on the left shows the cumulative distribution. [From DATA by Tree Age]

(1) How are problems solved? -- The users of DSS need a flexible mechanism that displays results quickly and interactively. Whether for demonstration or production use, a DSS must do more than simply display result values returned by the solver. Programs should offer some degree of insight into how the problem was solved.

Perhaps the most useful feature offered is the ability to perform sensitivity analysis. Sensitivity analysis shows the change in output due to a given change in one or more input variables. In the thesis survey of what users of DSS, designers, and educators felt were important features for DSS packages to have, respondents gave an average of 30 out of 100 points to sensitivity analysis, the most heavily DSS related weighted factor. A typical sensitivity analysis graph is shown in Figure 7.

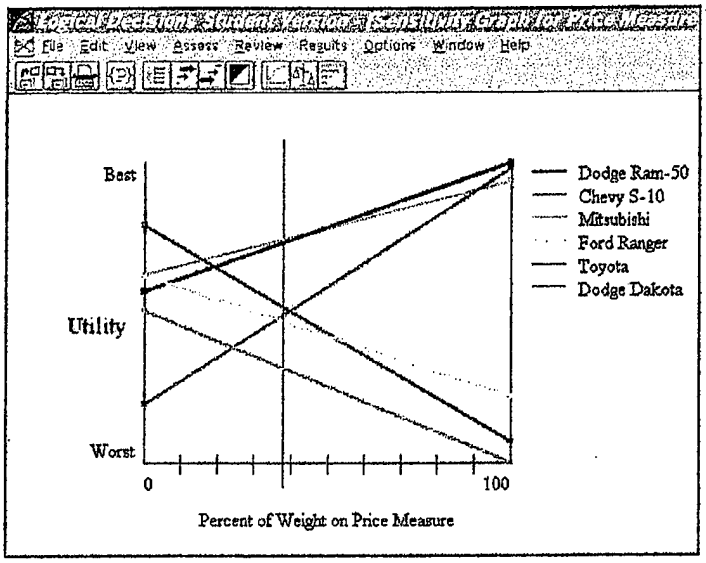

Figure 7 Sensitivity graph shows the change in an output variable when an given input variable is changed. [From LDW by Logical Decisions]

Nearly all decisions involve situations which are probabilistic in that the behavior of the system being modeled cannot be predicted with certainty because a degree of randomness is present. A probabilistic model attempts to capture the probabilistic nature of the system by requiring probabilistic data inputs and by generating probabilistic outputs. [Sprague, 1996] DSS users assigned 30 out of 100 available points to the importance of the ability to model this uncertainty. Some of the programs reviewed allow the user to enter a variety of statistical distributions in place of actual data values. LDW for instance allows the user to enter a point estimate, normal distribution, uniform distribution, discrete distribution, piecewise linear cumulative or three point estimate. The program will then show this uncertainty on the output as shown in Figure 8.

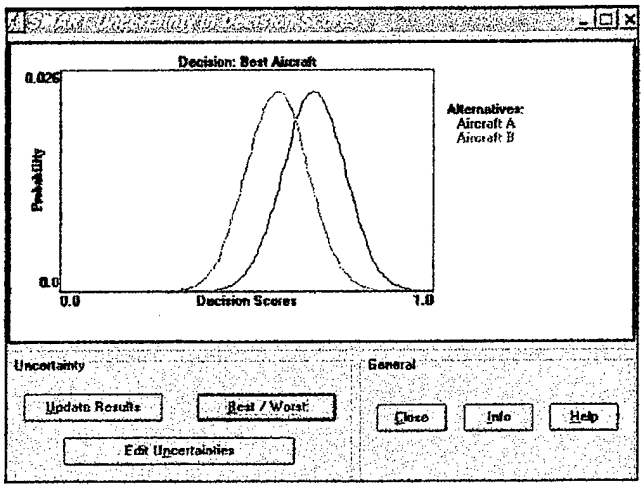

Figure 8 This chart shows uncertainty as a range of possible outputs in a decision where a normal distribution was assigned to one of the decision criteria. [From Decision Plus by Info Harvest]

(2) Explanations Of Recommendations -- Survey respondents gave considerable weight to the importance of a program providing insight into its recommendations. According to the designer of one of the popular packages:

> There are a few key elements to trigger the understanding of a user to the process of decision making. This hurdle can be overcome, often with a few minutes of proper instruction or guidance within the software. The trick is how to achieve this. More sophisticated users must be more aware of how to build models to represent a decision or process. Training courses are under development to assist both the basic user and the more advanced user on how to fully utilize the produce.

(3) Using the output -- In addition to viewing output on the screen, some of the programs allow the user to export graphical output to other applications for use in other programs such as a word processor. This is important since many decision will have to be written up and presented to others.

2. Data Management

It is increasingly critical for the DSS to use all the important data sources internal and external to the organization. This includes concepts, ideas and opinions that are important to decision making. In order to effectively manage data, a good DSS should con-

tain features for managing and manipulating data and for keeping track of different versions of the data. It is also desirable to be able to import and export data from other applications such as databases and spreadsheets.

a. DBMS Management Functions and Version Management

Desirable DBMS functions include such things as the ability to manipulate rows of data or to extract subsets of a database. The thesis survey asked about the importance that the program have DBMS functions. Though the survey respondents allotted only minimal importance to this feature, it is valuable to have at least minimal DBMS features available if working with large data sets.

Version management allows users to work with various versions of a database. This is important when the data is being used by different users or being modified for different trials. Again, this feature was judged relatively unimportant by all respondents but would be valuable.

b. Data Import and Export

The survey asked users how important it was for the DSS to be able to import and export data directly from other applications and databases. Surprisingly, corporate users and program designers allotted less than 15 points (out of 100 available design feature points) to this ability. Educational users allotted only 6 points. This would lead to the conclusion that in most cases, desktop DSS users are using the programs to model stand alone decisions vice repetitive ones which draw on an external data source. In the words of one DSS vendor:

> Some people seem to use data import/export extensively, but ... they are in the minority. ... most people do not have the kind of data used by decision analysis programs (e.g., probability data) already prepared and stored in different formats. In most cases, people seem to estimate, calculate, or derive this information for the specific purpose of building a decision-analytic model. And to the extent that such data is being developed solely for this purpose, there is no reason to add an extra "layer" of applications in order to import the data into a decision analysis program.
>
> Some specialized groups of users, such as epidemiologists (who can import probability data from databases) and financial analysts (who can import financial data from spreadsheets) probably use import/export features with substantially greater frequency than the overall population of decision analysts. This perception is consistent with the theory that such use is tied to the availability of preexisting raw data.

In spite of the lack of emphasis, this is an important feature. Being able to import and export data allows users to access corporate databases without having to re-enter data into a DSS. As more programs offer data exchange and data becomes more widely available, it is logical that DSS users will want to be able to extract data from corporate databases for use in DSS programs.

3. Model Management

Models provide the analysis capabilities for a DSS. Using a mathematical representation of the problem, algorithmic processes are employed to generate information to support decision making. Among the more heavily weighted features of DSS according to respondents to the survey was the ability of the DSS to build large complex models.

There are essentially two schools of thought regarding the model function of decision support systems. One is that the main purpose is to support the decision-maker in whatever style of decision-making chosen. The other is that the support, while suiting the decision-maker's individual style, must also be based on an appropriate theoretical paradigm. [Edwards, 1994] If a user is called upon to defend a decision, it may be more useful if the model used is an accepted one such as AHP. In the words of a DSS designer:

It is important to be able to recreate the "audit trail" that leads to any particular utility, so the math functions are important. However, this should be very easy unless the software uses a proprietary method.

Several of the multi-criteria based programs use accepted models such as AHP or SMART. Others use proprietary models.

Model management features of a DSS include features as being able to import and export model structure from other programs and to maintain control over versions of models.

Versions are most likely to proliferate when a model is being developed. Even relatively simple decisions can easily grow into models with hundreds of nodes. Version management features allow the user to modify a model and then return to a previous version if desired. This is an important feature, however, it received relatively little emphasis from users of DSS software.

E. SUPPORT

This section discusses the methods by which a user can receive help when learning to use a program and interpret its output. Help can come in a number of forms including paper and online documentation, sample exercises and tutorials, or Web based exercises. Companies offer various degrees of support from phone and email to full consulting. User preferences are discussed in the next chapter.

1. Vendor Support

What Aspects of DSS Modeling Does the Vendor Address? While evaluating the software available, it is important to determine what the vendors are offering to sell, and to whom. In many cases with DSS software there are services available. The software may come in any of several forms, and may be addressed to any of several kinds of users. Some vendors may not offer a broad enough range of services to meet the users needs, while others may have a motivation to sell things that you do not want. All six of the vendors who responded to the survey offer at least some consulting. At least one of the major DSS producers offers primarily consulting with software being only a sideline.

2. Training

Documentation can come in various forms including paper manuals, help files, embedded training, and now, tutorials located on the World Wide Web.

Embedded training is computer based. Far more than help routines, embedded training modules permit users to digress for a moment during a problem solving session to learn or relearn something with which they may be unfamiliar. They permit users to learn as they go and even to decide when they want or need a small refresher course. Self paced training permits users to learn at their own pace while eliminating scheduling, logistical and location problems. [Andriole, 1989]

F. SUMMARY

This chapter provided an overview of the basic features the potential user of a DSS must consider. Features included the type of DSS problem a particular package addresses and the technical requirements of a program. DSS packages consist of three components including the user interface, the database management system and the model management system. The important features of these components are summarized in Table 2 below. Desktop DSS are strongest in the user interface area, making extensive use of the Windows and mouse interface of a PC. Most desktop systems lacked DBMS and MMS features at any more than a rudimentary level.

The next chapter will discuss DSS as they relate to use in education, production and demonstration.

DSS Features
What Problems Does the Product Address: • Decision making under uncertainty • Multi-criteria decision making
User Interface Management System • Mouse and Windows support highly desirable • Clean orderly display which makes appropriate use of color • Dialog features menus, query or natural language, prompting, or form filling • Relative versus absolute data values • Bar chart and stacked bar chart outputs • Sensitivity analysis and ability to model uncertainty important and add insight • Ability of program to explain recommendations desirable
Database Management System • Data import and export desirable especially with large or recurring data needs • Version management desirable
Model Management System • Model import and export desirable • Version management important

Table 2

IV. DSS USE IN PRODUCTION, EDUCATION, AND DEMONSTRATION ENVIRONMENTS

A. INTRODUCTION

The previous chapter discussed some of the issues which affect all users of decision support systems. This chapter will look at specific users which have been classified into three categories, those who use the programs for production, those who use the programs for demonstration, and those who use the programs in education.

Not surprisingly, there were differences in what educators found important in DSS software and what production users found important. We received survey responses from six of the leading DSS software designers. One of the questions asked of them was to allocate 100 points between four categories of users: educational, strategic production, tactical production and demonstration. In this grouping, designers allocated an average of 53 points to strategic use and 24 points to tactical use while allocating only 15 points to the importance of educational use. It is not surprising that the responses received from production users of DSS software were more closely aligned with the views of the designers than were responses received from educators. Says the designer of one program:

> Our interests are not the same as the academic community - we have no theory to defend, only a need to ensure that client requirements are met as best as possible and at the highest technical standard. This means understanding how we can help the user in reaching the decision through the most appropriate mechanism.

B. PRODUCTION USE

A growing number of organizations have developed DSS for applications ranging from production control to strategic planning. As discussed in Chapter I, Section B. 1, decisions can vary in the degree of structure of the decision making task which they support. DSS are being used for one time ad hoc decisions as well as recurring institutional uses.

Desktop DSS are an ideal tool for managers faced with ad hoc decisions, the type managers face frequently. The packages reviewed for this thesis allow the user to quickly set up decision scenarios and solve problems. The programs are also suited for institutional uses, though they are somewhat limited by their scant data import and export capabilities.

1. Survey Responses

Among the respondents to the thesis survey, five were designers of DSS software and seven were experienced users. Although a statistically insignificant number, the inputs provide insight on what users of this type of software feel is important and serve to validate the assumptions made for this thesis. For the purposes of this survey, designers of DSS software were grouped with users. Since the designers interact with a number of users, their answers represent, to some extent, a broad view of what the typical user expects to see in a DSS. The survey asked users of this type of software as well as designers to suggest whether they felt the programs were more useful for strategic use or tactical use. In every instance, the designers of the software felt the programs were more appropriate for strategic use while users were more evenly mixed. In the case of the users, however, the small sample size likely skewed the data. The nature of these programs lend them more towards strategic use. Appendix H shows detailed responses for production users and designers.

2. Software Selection

Survey recipients were asked to rank between six criteria to consider when selecting DSS software including the length of time required to learn the program, the ease of use, the availability of multiple platform support including use on a network, cost and the power of the package. Users, as well as designers, ranked the ease of learning and using a package as the most important criteria with the power (variety of features, outputs, size of models) a close second. The cost of the package received relatively little emphasis. The emphasis of designers can be summarized in the words of one:

> We have endeavored throughout our history to offer extremely intuitive applications that have enough power to satisfy the most sophisticated users. This entails attention to the ease of the user interface, thorough and graphical output and the ability to interface with other programs.

3. Application Features

Survey respondents were asked to rate between ten applications related features broken down into user interface, data handling and modeling features. The details of these features were discussed in Chapter II.

Users assigned an average of approximately 30 points to the importance of a well designed user interface including mouse and windows support, a well laid out input interface and good output representations. All of the packages reviewed support Windows 3.1 though few specifically support Windows 95.

> Users as well as designers of DSS gave surprisingly few points to the data handling features of a DSS. They allotted the most points in this area to the ability to import and export data with little consideration given to version management or the availability of DBMS functions.

Users assigned a total of 44 points to the model management area with the most points being allocated to the importance of being able to build large complex models. Model version management earned nine of 100 points from DSS users. None of the packages reviewed incorporated version support other than saving files with different names.

4. Decision Support Features

The thesis survey asked production users to allocate points between five DSS related features including the ability to model uncertainty, use subjective data, enter utility functions, determine risk and perform sensitivity analysis. The ability to perform sensitivity analysis was considered the most important feature in this area followed by the ability to model uncertainty. This only makes sense. In a production environment, it is important that a manager not only be able to make a decision but also to understand and explain the

decision. Sensitivity and uncertainty analysis provide a valuable tool to perform this feature.

5. Support and Training Features

The survey asked users and designers to rate the importance of training functions including the availability of sample exercises and tutorials and whether the program provides explanations and insight. Most respondents felt that the availability of sample exercises was very important giving that feature 26 points. The availability of tutorials was just less important with 18 points. 29 points were allocated to the importance of the program explaining results with 28 points being assigned to the importance of the program providing insight into recommendations.

Production users were asked to rate the importance of six support features including: an online list of frequently asked questions, availability of discussion groups and mail lists, support via phone or email, the level of local support and the availability of online documentation. The availability of phone or email support was rated as the most important feature. Production users were unconcerned about being able to receive support via discussion groups or mail lists.

C. EDUCATIONAL USE

The use of technology is changing the expectations of students and faculty. Students who grow up in a technological age will not accept lectures that fail to draw upon the information resources on the Internet and elsewhere. Schools that do not provide their faculty with classrooms where dynamic audio and visual media are easily used will be unable to attract good faculty and good students. Like business and industry, campuses cannot afford to ignore technology.

This thesis makes no special distinction for "educational" software. In earlier years when computer time was scarce and interfaces were primitive, college courses often relied on the simplistic interfaces and slow, unreliable algorithms of "student" DSS packages whose performance was sufficient for exercises. Today students can be taught with the

same packages that practitioners use for applications of realistic size and complexity. Many of the packages reviewed are available at low academic prices, with the least expensive versions being limited to reasonably large number of variables and constraints. In the case of every package reviewed, a demonstration copy of the program was available for download on the World Wide Web.

1. Survey Responses

Among the respondents to the thesis survey, 14 were users who taught DSS at both the undergraduate and / or graduate levels. They used a variety of different DSS packages in their classes including spreadsheets. The survey asked educators whether their use of a DSS package in a decision support class was intended to teach the student how to use a DSS or whether it was used to support learning DSS concepts. Respondents were mixed in their responses with some leaning heavily towards teaching DSS use and others using the programs to support concepts. The overall response was nearly evenly split. The selection of a program for the class room will depend in large part on its intended purpose. Some programs reviewed follow traditional DSS thinking. For example, DATA allows the user to create traditional influence diagrams and decision trees. Criterium Decision Plus uses very traditional AHP diagrams. Either of these programs would be good choices for use by a professor whose main purpose is reinforcing DSS concepts. Other programs use less traditional methods. Which and Why would be a good choice of programs to demonstrate what packages are available but it's non traditional approach makes it less desirable for teaching concepts. Appendix F provides detailed survey responses from educators.

2. Software Selection

In the thesis survey educators were asked about five primary criteria to consider when selecting DSS software including the length of time required to learn the program, the ease of use, the availability of multiple platform support including use on a network and cost.

The length of time required to use a DSS and the closely related criteria, ease of use, were ranked as very important by respondents to the survey. These two features accounted for an average of almost 60 points out of 100 points allotted the selection portion of the survey. This is to be expected given the relatively short time which students have to learn and use a software package in the classroom and the likely possibility that more than one program will be taught.

We expected multiple platform support would be an important criteria given the variety of platforms typically used in schools. Out of 100 points available in the selection portion of the survey, however, educators allotted only 3 points to cross platform support and ten points to network use. This is attributable to the growing percentage of WINTEL based computers and the decreasing numbers of Apple Macintosh.

Not surprisingly, the cost of acquiring a package represented 31 of the 100 points available in this section. The DSS packages reviewed here range in price from $20.00 to over $10,000. In every case, there are trial versions of the programs evaluated available for download from the World Wide Web, however, some are quite limited in their usefulness as instructional tools. In some cases, model size is limited, a small drawback for education purposes. In other cases you can't save or print results, a much bigger drawback.

3. Application Features

The thesis looked at a variety of application features which should be useful to users in education. The survey recipients were asked to rate between user interface, data handling features and model features. Each of these areas are further subdivided as discussed below.

Important features of the user interface include mouse and Windows support, input characteristics and output representation. Respondents allotted twenty points to the necessity of having mouse and Windows support. Respondents allocated only 9 points to input characteristics but gave 16 points to output. The quality of both these items varies greatly from program to program.

Educators gave relatively few points to the importance of a packages data handling characteristics. Database management functions and import export capabilities each received about 10 points while version support received only 4 points. For the purposes of classroom use, it is unlikely that users will require data import or export since they will likely be working with small demonstration data sets. Likewise, it is unlikely that there will be many versions of a given database.

Collectively, the ability to build a variety of models which may be large and complex, gained 25 out of 100 points. Some of the programs which model uncertainty will build both influence diagrams and decision trees while others work only with the later. The programs which use multi-criteria decision making use AHP and in some instances SMART. As with the model management features, version support was of little importance to educators. This is to be expected as version support is more important in collaborative efforts such as might be found in business. The ability to export models to other applications was also important, earning 17 points. Most of the DSS software reviewed did a poor job of export.

4. Decision Support Features

The survey asked educators to allocate points between five DSS related features, the ability to model uncertainty, use subjective data, enter utility functions, determine risk and perform sensitivity analysis. Each of these features was deemed equally important with uncertainty and sensitivity analysis receiving slightly more preference. The programs reviewed perform these function in a variety of ways. Some programs will allow the user to enter subjective data while others require numeric entries. Most of the programs allow some form of sensitivity analysis. Some, such as LDW, allow the user to enter statistical data where actual data isn't available and then display uncertainty in decisions.

5. Support and Training Features

Educators were asked to rate the importance of built-in training functions including the availability of sample exercises and tutorials and whether the program provides ex-

planations and insight. Most respondents felt that the availability of sample exercises and tutorials were very important giving those features 27 and 33 points respectively. All of the programs come with sample problems. 21 points were allocated to the importance of the program explaining results with 19 points being assigned to the importance of the program providing insight into recommendations.

The DSS reviewed offer various methods of support for users. Educators were asked to rate the importance of six support features including: an online list of frequently asked questions, availability of discussion groups and mail lists, support via phone or email, the level of local support and the availability of online documentation. The availability of online documentation was rated as the most important feature. The other five features each received equal ratings.

D. DEMONSTRATION

Desktop systems are quite useful at the prototyping stage, where the work is focused on building an acceptable model and demonstrating sufficiently promising results to justify a larger investment. To some extent, educators also build demonstration systems which are used to support a lecture on a particular type of decision making.

Depending on the type of ultimate model planned, any of these programs might be useful for prototyping. The first feature required is that the program support the type of model ultimately planned for development. The length of time required to construct a problem is also important as is a flexible UIMS which can simulate the full scale product. Of less importance is a full featured DBMS since small demonstration data sets will probably be used.

E. VARIATIONS ACROSS USE CATEGORIES

There were some significant differences in what was important to educators and to production users as well as many similarities. When rating selection criteria, educators were most concerned about the time it would take for their students to learn the package as well as the cost of the package. This only makes sense considering the high cost of

some software packages and the limited amount of time available for a student to master a program. Production users not surprisingly were most interested in the "power" of a packages. They too were interested in ease of use and learning time, though less so than educators.

1. Application Features

Both educational users and production users assigned roughly the same number of points to features in this area. Surprisingly, neither placed much emphasis on the data handling capabilities of the programs, placing emphasis instead on the user interface features and the ability to build large complex models.

2. DSS Features

There were some differences in DSS features educators and production users found important. Educators allotted three times as much emphasis to the importance of a programs ability to model utility functions. In a pure academic setting, this would be desirable in a program since the professor could interactively demonstrate this important concept. In a production setting, often the manger may prefer to simply express his preference for one choice over the next, leaving the details of utility to the underlying program.

Production users ranked the importance of being able to measure uncertainty and sensitivity more strongly than did educators. Although educators are interested in being able to demonstrate these features in the classroom, production users must have this information to make informed decisions. Thus the higher ranking.

3. Support and Training

In the area of support and training, educators for obvious reasons were more interested in online tutorials than were production users. Educators were also more interested in being able to receive support through online discussion groups and mail lists while production users preferred to be able to pick up the phone and call someone. Both produc-

tion and educational users weighted the importance of online documentation highly. Designers, however, gave this relatively little priority, apparently preferring to provide written documentation.

F. SUMMARY

Different DSS features are more important to some users than others. Designers of DSS software not surprisingly, place more emphasis on the production use of their programs than on education use. As such, there priorities are more closely aligned with production users than educators.

In a production setting, DSS are perhaps more practical for non-recurring strategic decisions. The limited data import and export capabilities of today's products make them less suited for recurring decisions which may rely on external data. DSS can make excellent supplements to courses of instruction which teach DSS. They can be used either to teach DSS or to demonstrate interactively the concepts of decision trees or multi-criteria decision making. Table 3 summarizes production and educational users priorities when using DSS. The following chapter reviews some of the leading DSS packages demonstrating the current "state of the art" as it relates to the feature set discussed in this and the previous chapter.

↑ Judged important ↓ Judged less important	**Production Users**	**Educational Users**	**All Users**
Selection considerations	↑Power ↓Cost	↑Length of time to learn ↑Cost	↑Well designed UIMS ↑Ease of use ↓Multiple platform support
Application features		↑Ability to build different types of models ↑Model Export	↑Ability to build complex models
DSS Features	↑Sensitivity analysis ↑Modeling uncertainty		
Training	↑Explanation of results and insight	↑Tutorials	↑Sample exercises
Support	↑Phone support	↑Online documentation	

Table 3

V. DESKTOP DESCISION ANALYSIS SOFTWARE

A. INTRODUCTION

Having discussed the feature set which define a desktop decision support system, this chapter provides an overview of currently available packages. This thesis will not attempt to review the packages in depth. New releases are being introduced too fast to make such an assessment of lasting value. The popular press contains numerous reviews of such packages, some of which are listed in the bibliography. This review will concentrate on how the currently available packages meet or do not to meet the requirements set forth in the preceding chapters. Table 4 shows the packages reviewed and the producer. Appendix B contains a chart detailing more specific information on these programs.

Software Title	Company
@RISK, TopRank	Palisade Corp.
AliahTHINK!	Aliah Inc.
Criterium Decision Plus	InfoHarvest Inc.
Decide Right for Windows	Avantos Performance Systems Inc.
Decision Analysis by TreeAge (DATA)	TreeAge Software Inc.
Decision Pro	Vanguard Software
DPL	Applied Decision Analysis
Expert Choice Professional	Expert Choice Inc.
Logical Decisions	Logical Decisions
Which & Why	Arlington Software Corp.

Table 4

B. TECHNICAL CONSIDERATIONS

None of the packages reviewed possessed unusual hardware requirements. A few require 8 Mb's of RAM but most will run with 4 Mb's. All packages will run in the Windows 3.1 environment; many also have versions designed for Windows 95. Several still have DOS versions available. A few are available for Macintosh. Technical considera-

have DOS versions available. A few are available for Macintosh. Technical considerations are a go, no go situation with which most users are familiar. Appendix B shows a matrix summarizing the programs requirements.

All of the packages listed below are devoid of security features such as password protection of files and model designs. Even where intended for use in network situations, there is no protection against unintentional or unauthorized modification.

C. USER INTERFACE MANAGEMENT SYSTEM

The user interface of the programs reviewed vary greatly though all are relatively easy to learn and to use. The figures in this section show some of the user interfaces used to set up problems and make comparisons.

There is considerable difference in the quality of the displays of desktop DSS software. Some adhere closely to the principles of visual design whereas other pay little attention.

1. Building Decision Problems

Figures 9 through 15 show some of the variety of input methods offered by the packages reviewed. For the most part, desktop DSS offer the user few options for constructing decision problems. Most make use of Windows pull-down menus and toolbox buttons which allow the user to "construct" a problem on a clean screen. A few of the programs allow the user to start with a "brainstorming" feature. This feature allows the user to list random thoughts in a "note pad" area of the screen, then arrange these thoughts hierarchically and finally convert the list to a decision matrix.

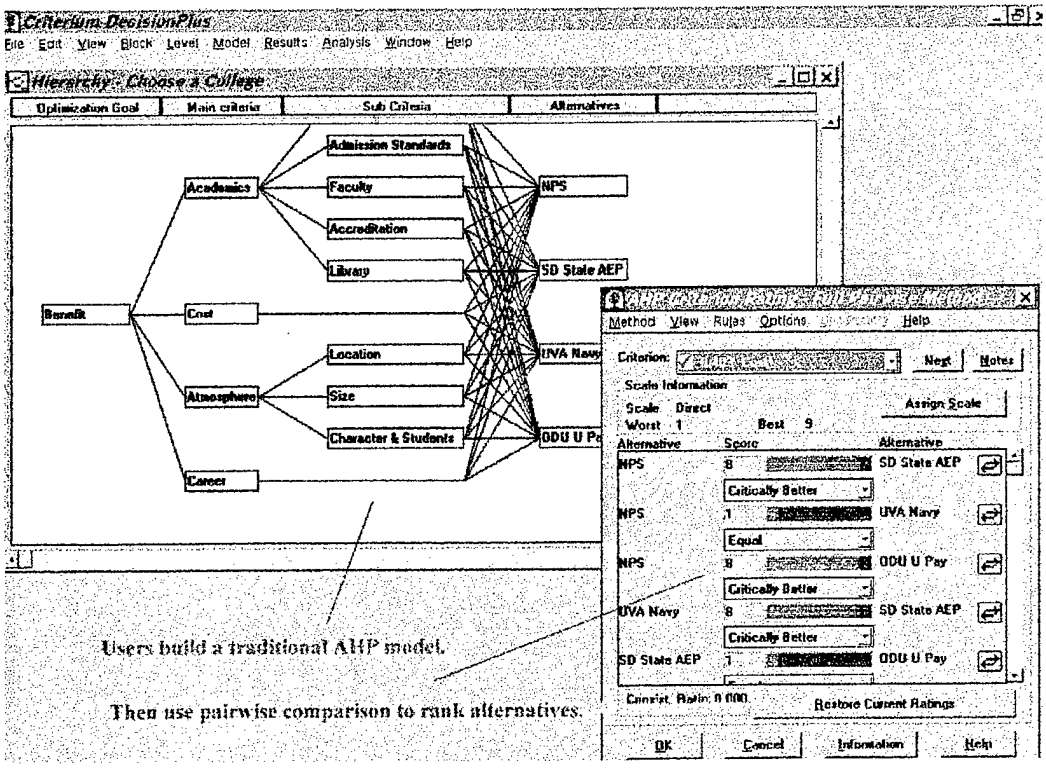

Figure 9 Criterium Decision Plus uses a traditional AHP graph to design the model. Values can be entered using either pairwise comparison or absolute scores. The user can select either AHP or SMART as the analysis method. [From Decision Plus by Info Harvest]

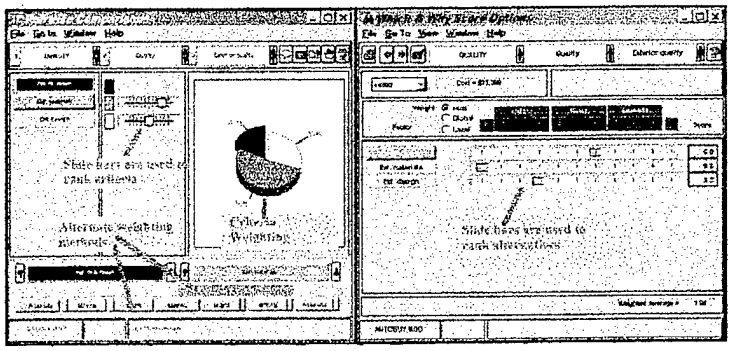

Figure 10 Which & Why uses slide bars to set up a pairwise comparison. Once decision criteria are prioritized, the user selects subjectively between the different outcome variables as they relate to each criteria. A difficulty with this method is that if the user is weighing a number of alternatives, he must remember the score assigned to a given data value. [From Which and Why by Arlington Software]

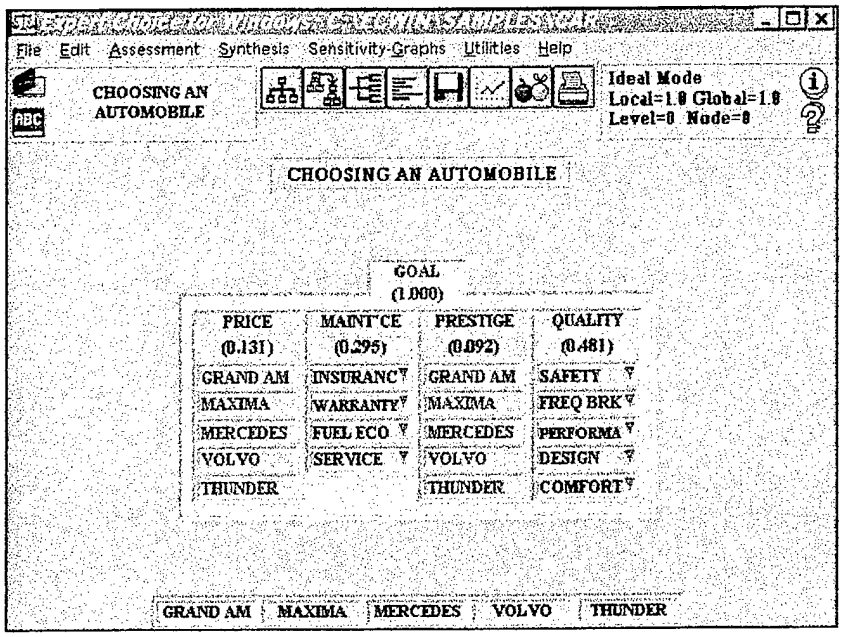

Figure 11 Expert Choice uses a matrix based on AHP to set up the decision model. [From Expert Choice by Expert Choice]

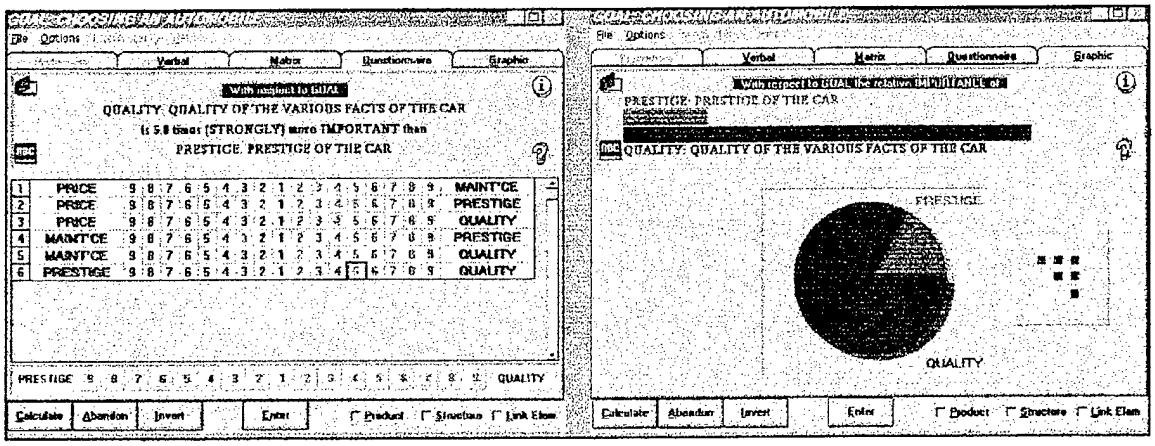

Figure 12 Once the decision model is set up in Expert Choice, users can chose several methods of weighing alternatives, a matrix based method shown on the left, or a graphical method, on the right. [From Expert Choice by Expert Choice]

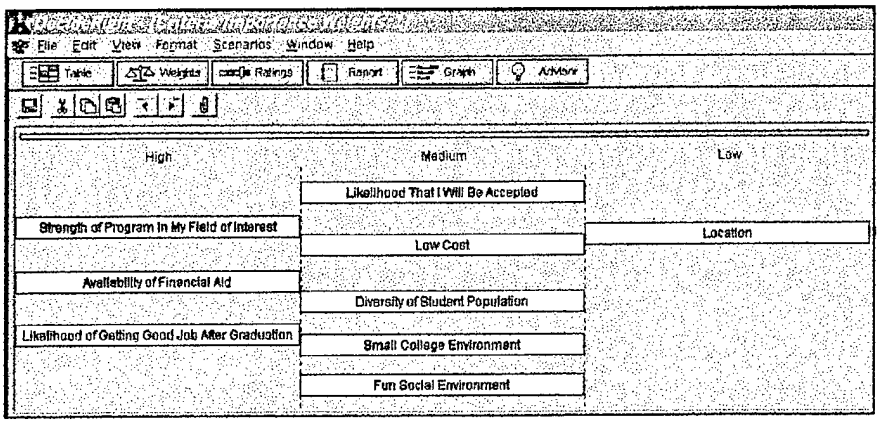

Figure 13 Decide Right uses a less traditional methodology. In ranking criteria, the user drags boxes corresponding to the different criteria towards the top left as they become more important. [From Decide Right by Avantos Performance Systems]

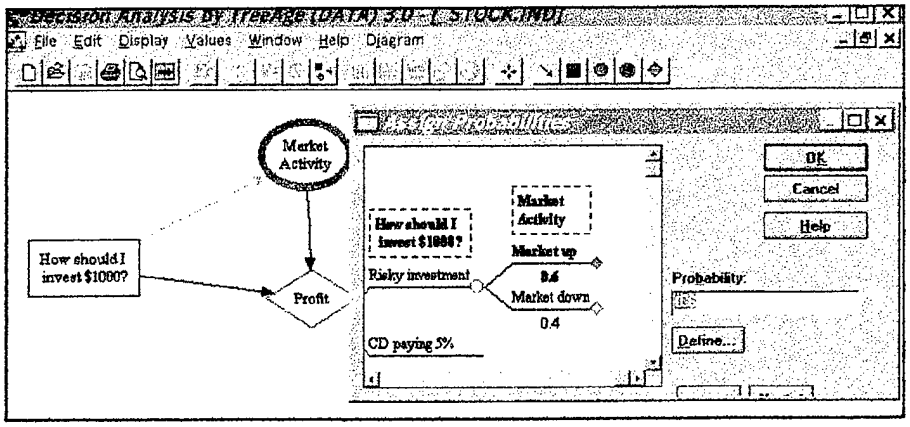

Figure 14 DATA uses influence diagrams to formulate the decision model. Once the diagram is drawn, the user then uses pop up boxes to enter probabilities and values about the various nodes. The influence diagram may then be converted into a decision tree. DPL works in a similar manner. [From DATA by Tree Age]

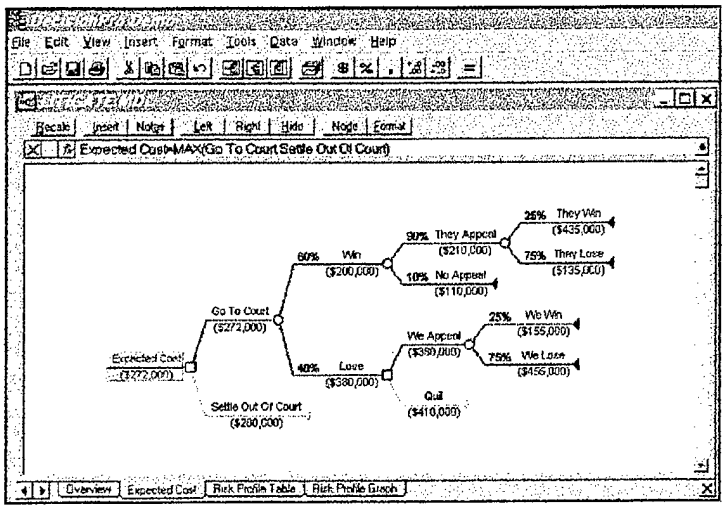

Figure 15 In Decision Pro the users starts with the decision tree view. Users build the tree node by node, entering data values and probabilities as they go. [From Decision Pro by Vanguard Software]

2. Outputs

Outputs from the programs have more in common than the overall interfaces. The basic output of all of the AHP based programs is a bar chart showing a ranking of outputs as shown in Figure 16. Most programs also offer a stacked bar chart which shows the contribution from each of the criteria. Figure 17 shows this type of chart. Decide Right will print a "plain English" decision report and export it to a word processor for editing.

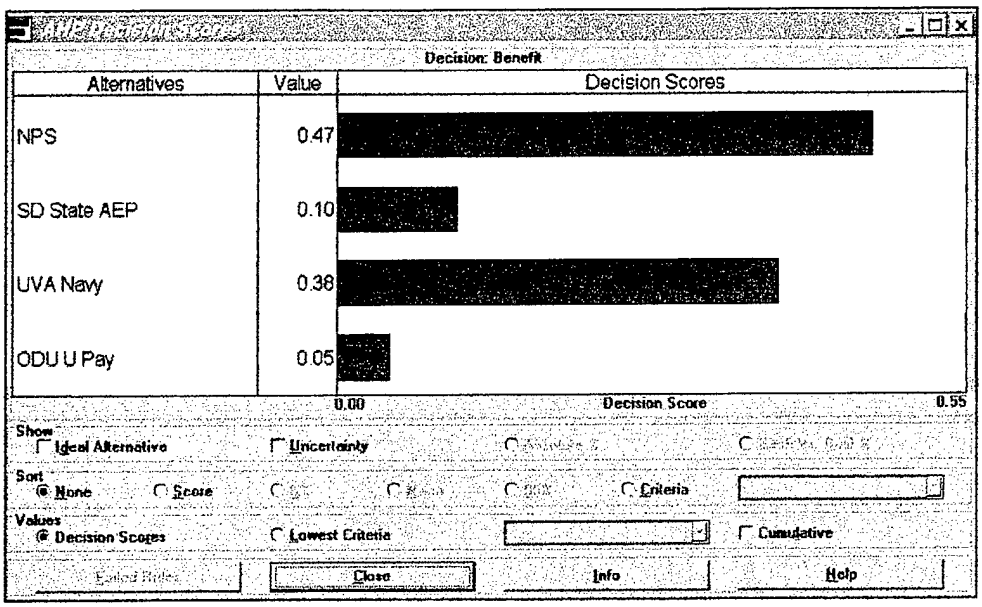

Figure 16 Criterium Decision Plus and most programs provide a bar chart which shows overall score of each output variable. [From Decision Plus by InfoHarvest]

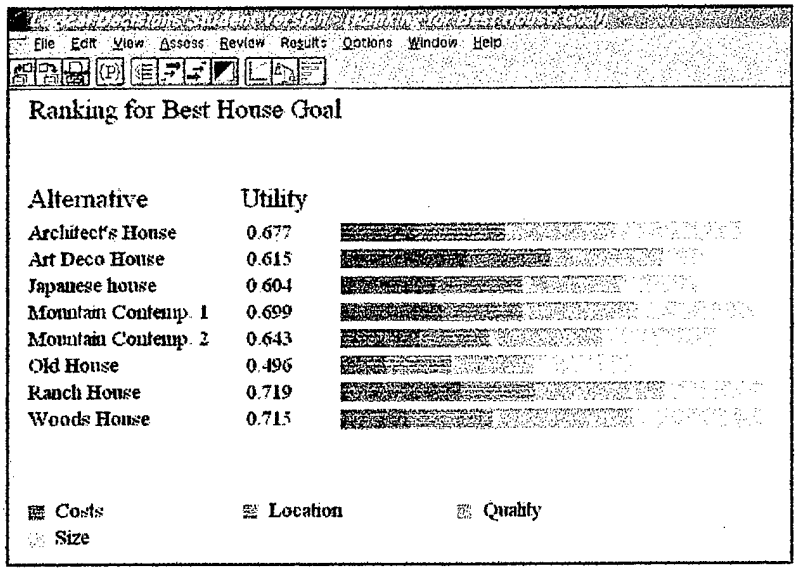

Figure 17 Several of the programs provide a breakdown of which criteria contributed most to the output. This allows the decision maker to determine which criteria contribute most to the various outcomes. [From LDW by Logical Decisions]

Programs offer a variety of ways to measure sensitivity, an essential ingredient of a good DSS. Figure 7 shows the traditional sensitivity chart. Some programs offer the useful feature of dynamic sensitivity as shown in Figure18.

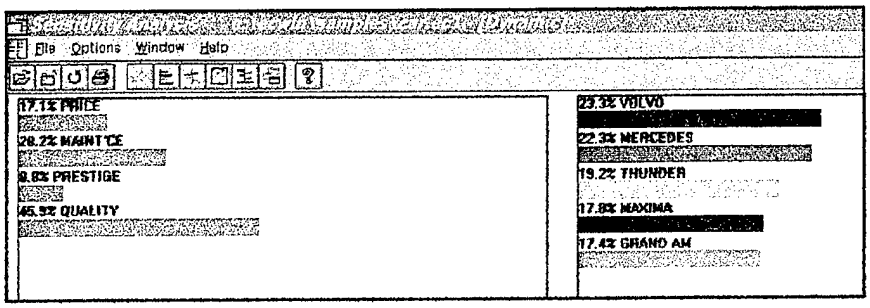

Figure 18 Some programs offer dynamic sensitivity analysis. In this program, as the user adjusts the criteria weights (shown on the left) using the mouse, the output recommendations (on the right) adjust accordingly. This allows useful insight into the importance of different input variables. [From Expert Choice by Expert Choice]

Scatter diagrams, Figure 19, and spider (or Radar) diagrams, Figure 20, provide the user additional ways of reviewing data.

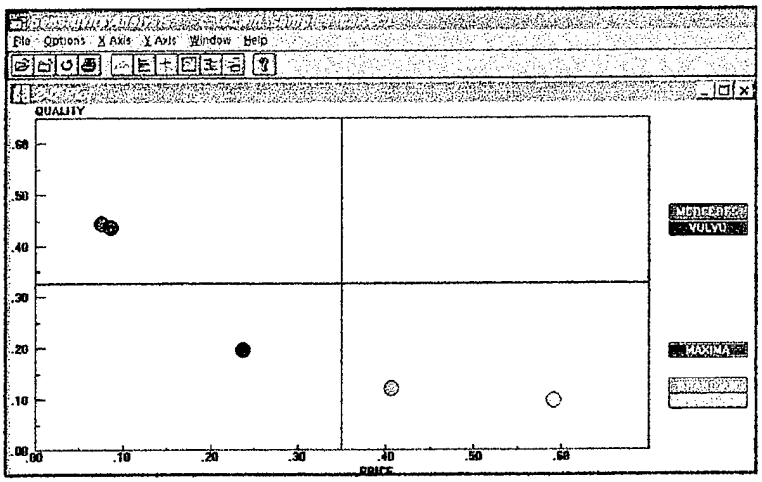

Figure 19 Some multi-criteria programs produce a scatter diagram which allow the decision maker to compare two variables for each alternative. [From Expert Choice by Expert Choice]

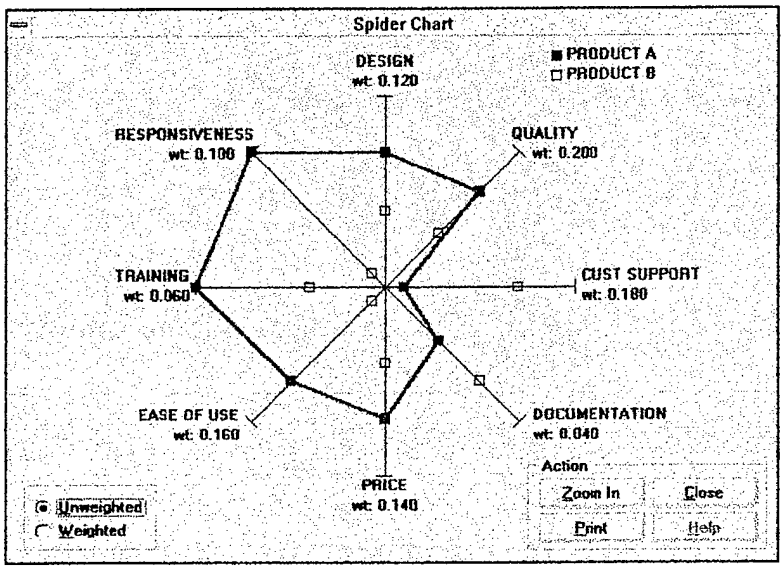

Figure 20 One program produces a Spider (or Radar) chart which shows weights assigned to different criteria. [From AliahThink by Aliah]

Decision tree based programs such as DATA or Decision Pro produce risk profile graphs as shown in Figure 21. This graph shows the user the range and likelihood of outcomes.

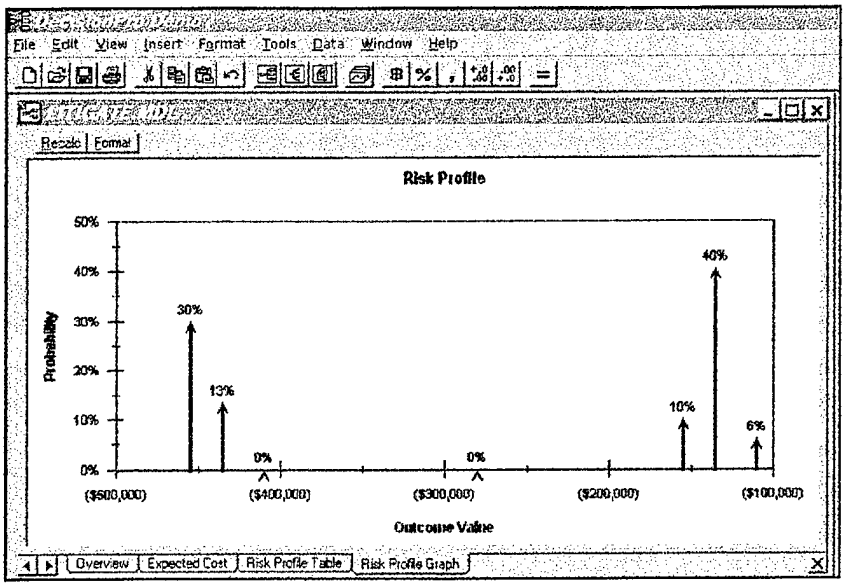

Figure 21 Programs which use decision making under uncertainty provide risk profile graphs. These graphs show the predicted likelihood of the various possible outcomes. [From Decision Pro by Vanguard]

3. Macros and Programming

With the exception of the spreadsheet add-ins, none of the programs provide for macros though AliahThink does offer a form of programming which allows the user to write customized routines. All of the programs allow models to be built and saved and then run by other user thus allowing a sort of "expert knowledge base." None of these programs work well with automated routines such as a user might write with Delphi or Visual Basic though an experienced programmer could force the programs to work with considerable effort.

D. DATA MANAGEMENT SYSTEM

The programs reviewed offer fairly weak DBMS features. In most cases, once data is entered the user is unable to perform features such as search and query or to extract subsets of the data. None of the programs offer version support. As an alternative, however, all programs allow the user to use the "save as" feature to save different data sets and rankings.

As discussed in Chapter III, Section D.3.b., a key factor to consider when selecting the system is the type of data which will be used. If the decision problem being solved uses absolute vice relative values, the choice of programs is limited to those which will accept actual data. LDW and Decision Plus are examples of programs which allow the user to enter numerical data and assign utility functions. Other programs, such as Which and Why and Decide Right force the user to make pairwise comparisons between the different decision variables. This method essentially forces the user to determine a utility function value. Not being able to enter data is a limitation in some cases, however, for a simple decision where the user doesn't wish to spend time gathering data, a subjective comparison may suffice. For example, if ranking the desirability of the fighter aircraft with a top speed of mach 1.5, the user might choose a score of eight of ten or nine of ten where as a plane with a speed of mach 1.4 might be assigned a score of seven or eight. A significant draw back to this method is that when entering large amounts of data, the user might be inconsistent in assigning scores.

Some of the programs offer data import and export capabilities. None perform the task in a completely straight forward manner, however, most will create a comma delimited file and some will save data in other formats such as Microsoft Excel or Lotus 123. Table 5 shows a sample export table from Expert Choice. Numbers indicate the corresponding utility value of each criteria. Table 6 shows a similar output produced by LDW.

		Car
PRICE		0.16447
	GRAND AM	0.04785
	MAXIMA	0.02784
	MERCEDES	0.00899
	VOLVO	0.01022
	THUNDER	0.06957

Table 5 Sample export table showing utility values assigned to price. [From Expert Choice by Expert Choice]

ALTERNATIVES				
NAME	Price	Power	Fuel Economy	Styling
Chevy S-10	10000	140	16.5	Ugly
Mitsubishi	11000	109	21.25	Mediocre
Toyota	15000	125	21	Mediocre
Ford Ranger	14000	160	17.5	Attractive
Dodge Ram-50	9000	109	23	Muscular
Dodge Dakota	17500	175	15.5	Nondescript
NOMORE				
ALTERNATIVE UTILITIES				
NAME	Best Truck	Cost	Performance	Styling
Chevy S-10	0.433423794	0.72134414	0.055692126	5
Mitsubishi	0.715351046	0.824600757	0.600205822	3.848591549
Toyota	0.465027273	0.3	0.721473789	
Ford Ranger	0.420115691	0.322454794	0.521369844	1
Dodge Ram-50	0.691738966	0.733333435	0.61926907	2
Dodge Dakota	0.250020476	0.148733611	0.392523047	3
NOMORE				

Table 6 Sample export tables showing data entered into program (top) and utility scores (bottom). Unfortunately, these tables contain only numeric data, not the formulas which were used to calculate the numbers. [From LDW by Logical Decisions]

E. MODEL MANAGEMENT SYSTEM

The model management system of the DSS reviewed are fairly rigid which is expected of a DSS generator. The programs take different approaches to solving decision problems. Among the programs which solve decisions under uncertainty, all use decision trees to solve the problem. DATA and DPL offer the user the choice of starting with an influence diagram. Decision Pro starts with the decision tree. Of the programs which solve multi-criteria decisions, the programs fall into two broad categories, those that use

fairly traditional methods such as AHP or SMART and those which use unique decision models. LDW or Decision Plus are examples of programs which use traditional decision analysis models while Decide Right and Which and Why use their own models. None of the programs offer you the ability to export models to other applications. Some of the programs offer a form of version support. DATA and Decide Right for instance, allow the user to save different versions of a model and then recall them later. In most program the user must use the "save as" command to save different versions of the model as different file names.

F. GROUP FEATURES

Though the programs reviewed for this thesis are not categorized as group decision support systems, a few do offer group DSS features. Which and Why allows multiple users to rank their preferences and combines these preferences into a group decision. Different weights can be assigned to different decision makers. Decide Right allows the user to enter different scenarios which can be compared graphically. Group features may be desirable, especially in higher level decision making where decisions are frequently made by group consensus.

G. SUPPORT

Program support and instruction are provided in several manners including help files, tutorials, documentation, and various modes of operation. All of the programs come with sample problems included in the documentation.

Online help varies from program to program. Where as some offer only basic information about the main features of the program, some offer a virtual course in DSS. Criterium Decision Plus, for instance, discusses in detail AHP and SMART, the decision making process and how to analyze output. Decision Pro offers a similar level of detail for problems involving decision making under uncertainty. Others programs, such as LDW or DATA, offer only basic information about the program features. A very useful feature found in some programs is the presence of a HELP buttons on individual windows

as shown in Figure 22 This allows the user to step back for a moment and refresh their knowledge on a given feature.

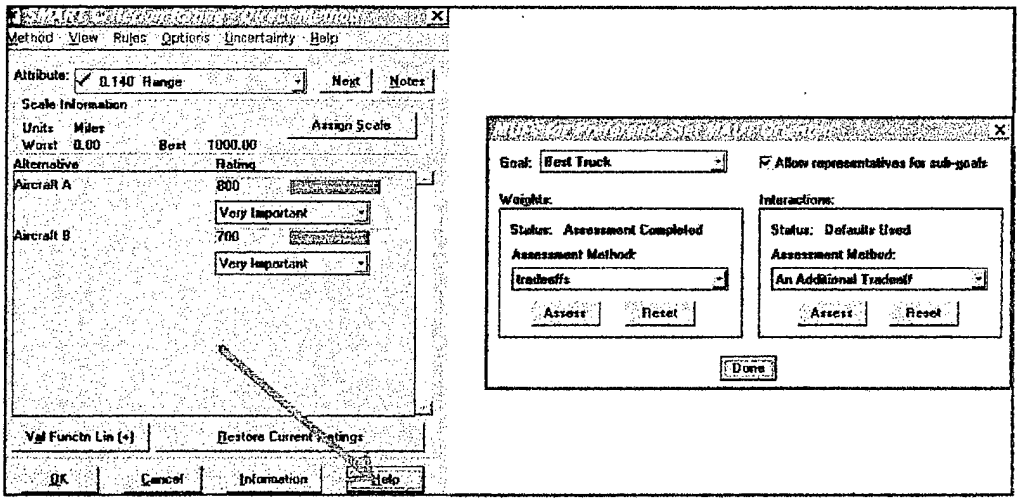

Figure 22 The figure on the left has a help button on each window in case the user wants more help on the given feature. The figure on the right doesn't. [From Decision Plus by Info Harvest and LDW by Logical Decisions]

Some of the programs have online computer tutorials, and all come with sample problems which the user can work through. Expert Choice's tutorial includes onscreen movies which show the novice user how to use the program. Some have tutorials which can be run on the World Wide Web.

None of the programs offer different expert and novice modes of operations though in Decide Right, the user can "turn off" pop up screens which offer instructions once they are familiar with the program. Notwithstanding, many of the programs offer the user different methods of accomplishing the same task such as pull down menus for the inexperienced user to control-key functions for the more experienced.

Most of the vendors provide some degree of consulting services and on sight training and decision coaching. Vendor Web sites discuss the level of services available.

H. SPREADSHEET ADD-INS

Spreadsheet add-ins offer an alternative method of conducting analysis. Though not traditional DSS, these programs bring a greater degree of analysis capability to a program, the spreadsheet, with which many are already familiar.

The techniques of risk analysis provide powerful tools to decision makers in managing decisions subject to uncertainty. Using the traditional spreadsheet, users can enter single point estimates of variables and predict a single output. By manipulating the variables, the users can look at a range of outputs, however, with multiple variables this can quickly become a burdensome task. A limited number of trials with varied data, or a non systematic approach can lead to an output which provides little insight. Spreadsheet add-ins attempt to solve this problem. These programs allow users to vary input to perform a number of simulations and to show a range of potential outcomes. Input can be varied in a variety of methods including multiple point estimates and over 20 statistical distributions. The output can then be viewed in a number of ways including distribution graphs, sensitivity graphs, and text output.

Perhaps the biggest advantage of these programs is that they run inside a spreadsheet thus making full use of the spreadsheets powerful interface and programming capabilities. All spreadsheet features are available including data import and export, object embedding and linking (OLE), macros, and more. What is perhaps most important is that most users are familiar with spreadsheets eliminating the need to learn to use an entirely new package. Figures 23 through 26 illustrate the features of the spreadsheet add-in.

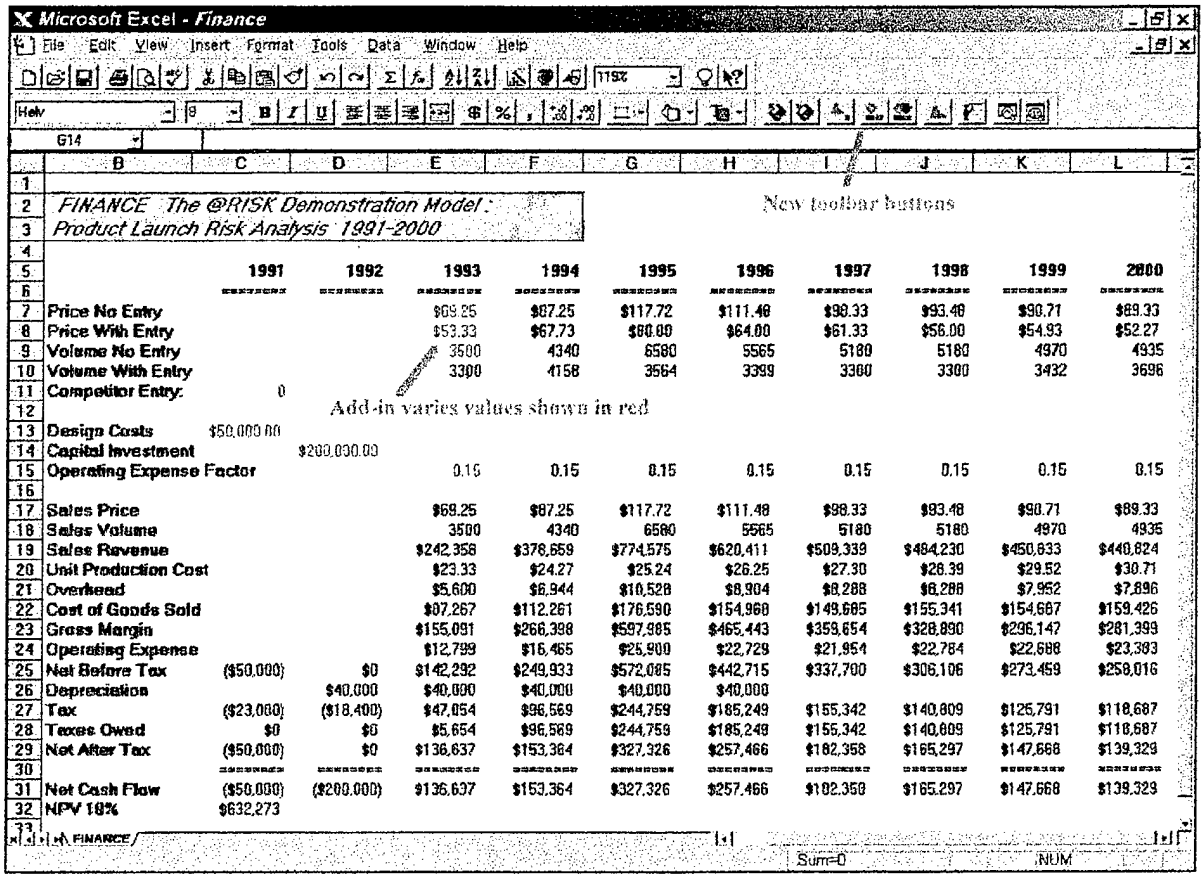

Figure 23 The user starts in the traditional spreadsheet. In this example a company is starting a new product line. The bottom line figure is the net present value of the cash flow over ten years. The initial price of the new product and the start up costs will be varied using various statistical distributions. Note the added toolbar buttons. The user selects fields to vary (shown in red) and then starts the simulation. [From @Risk by Palisade]

Name	NPV 10%	Net Cash Flow	Net Cash Flow	Net Cash Flow	Net Cash Flow	Net Cash Flow	Net Cash Flow
Description	Output	Output	Output	Output	Output	Output	Output
Cell	C32	C31	D31	E31	F31	G31	H31
Minimum =		-75646.2	-280580.1	-9888.726	22638.75	38111.91	-4639.875
Maximum =		-22548.08	-120078.3	191264.4	242291.1	508896.4	403311.8
Mean =		-49985.11	-200062.4	106150.1	139525.3	221368.1	166554.2
Std Deviation =		9932.364	29812.23	42135.32	34608.95	118536.3	101440
Variance =		9.865186E+07	8.88769E+08	1.775386E+09	1.19778E+09	1.405066E+10	1.029007E+10
Skewness =		9.264262E-03	-.0146575	-.3741564	-6.524616E-02	.3353366	.2678197
Kurtosis =		2.847248	2.865179	2.613093	4.189755	1.770231	1.730284
Errors Calculated =		0	0	0	0	0	0
Mode =		-52373.52	-199353.7	97920.45	147928.7	345919.2	95264.75
5% Perc =		-67014.53	-250297	28921.51	74035.14	80599.64	37960.39

Figure 24 The program produces a variety of statistics for the resulting output. [From @Risk by Palisade]

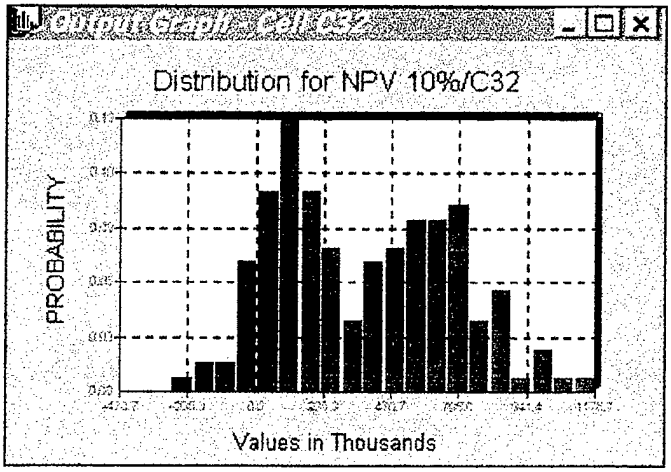

Figure 25 This graph shows the probability distribution for the net present value in this problem. This give the decision maker much greater insight than a single point estimate. [From @Risk by Palisades]

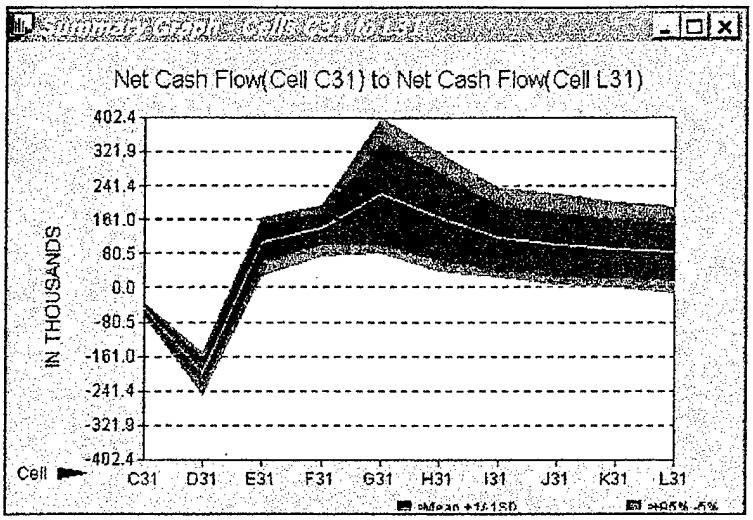

Figure 26 This graph shows the potential range of values of cash flow over the subsequent ten year period [From @Risk by Palisade]

VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The primary focus of the software vendors continues to be on analysis features rather than support for non-analysts in structuring the problem. These analysis features are useful to all users and critical for the insight that decision makers need. However, the result is that there are relatively few people that are qualified and comfortable in using these packages. These packages will never become as widespread as spreadsheets and databases as long as the user has to be a highly educated analyst. [Booed, 1996]

Users currently have the choice of two levels of software, those designed for someone with experience in DSS and those with less experience. Programs such as LDW and Decision Plus, as well as the decision making under uncertainty based programs, assume that the user has considerable knowledge in decision methods. Other programs, such as Which & Why and Decide Right, use a less traditional techniques for reaching decisions. These programs, however, require little DSS knowledge from the user and essentially guide the decision maker through making the decision relying on intuitive interfaces. The type of software most appropriate in a given situation depends on the users needs.

There are a variety of excellent programs available which offer differing approaches to decision making. As discussed in this thesis, a careful match between the users needs and the features offered by these program should provide a product which will enhance the decision making or educational process.

B. RECOMMENDATIONS

This thesis touched only briefly on group support features which are becoming much more common. Further research on these program in the format of this thesis would be beneficial. This thesis did not focus on real world scenarios where use of a desktop DSS generator would be beneficial. Research involving the practical use of these powerful programs in DoD would be useful.

LIST OF REFERENCES

Andriole, Stephen, *Handbook of Decision Support Systems*, Tab Books, Inc., 1989

Adelman, Leonard, *Evaluating Decision Support and Expert Systems*, John Wiley & Sons, Inc., 1992

Booker, Ellis, "Pushing decision support beyond executive suite", *Computerworld,* Volume: 27 Issue: 51 Dec. 20, 1993, p: 65

Booed, Dennis, "Aiding Insight III", *OR/MS Today*, Aug. 1996, p. 73-79

Edwards, John S; Kidd, John B, "Some Experiences With The Teaching Of Decision Support Systems To Management Students", *Journal of the Operational Research Society*, Volume: 45, Issue: 4, Apr. 1994, p: 376-383

Sprague, Ralph; Watson, Hugh, *Decision Support for Management*, Prentice-Hall, 1996

Young, Lawrence, Decision Support and Idea Processing Systems, William Brown Inc., 1989

BIBLIOGRAPHY

@RISK Home page, Palisade Corp., http://www.palisade.com/products/index.html

AliahTHINK! Home page, Aliah Inc., http://www.aliah.com/

Angehrn, Albert A; Jelassi, Tawfik, "DSS Research And Practice In Perspective", *Decision Support Systems*, Volume: 12, Issue: 4,5 Nov. 1994, p: 267-275

Booker, Ellis, "Whole Lotta Guesswork Goin' On", *Computerworld*, Volume: 28, Issue: 1, Dec. 27, 1993, p: 53

Caster, Kathleen, "Brainstorming And Decision Support: Expert Choice, Version 8.0", *PC Magazine*, Volume: 13 Issue: 19 Nov. 8, 1994, p: 223

Criterium Decision Plus Home page, InfoHarvest Inc., http://www.infoharvest.com/,

Darling, Charles B., "A DSS Triology/Part I Build an App Development Framework for DSS", *DATAMATION*

Davis, J Steve; Kanet, J J, "Developing An Application-Specific Interactive System Based On A Spreadsheet Package", *Journal of Systems & Software*, Volume: 25 Issue: 2 May 1994, p: 201-206

Decide Right for Windows Home page, Avantos Performance Systems Inc., http://www.avantos.com/

Decision Analysis by Tree Age Home page, Tree Age, http://www.treeage.com/TreeAge Software, Inc.

Decision Sciences Home page, http://www.lumina.com/DA/decisionsciences.html

Eierman, Michael A; Niederman, Fred; Adams, Carl, "DSS Theory: A Model Of Constructs And Relationships", *Decision Support Systems*, Volume: 14, Issue: 1, May 1995, p: 1-26

Expert Choice Professional Home page, Expert Choice Inc., http://www.expertchoice.com/

Fernandez, Abel A., "Expert Choice", *OR/MS Today*, August 1996, Volume 23, Number 4

A Buyer's Guide II", *CSTS Newsletter*, Vol. 17, No.2, Fall 1996, Institute for Operations Research and the Management Sciences Computer Science

Gundersen, David E; Davis, Donald L; Davis, Donna F, "Can DSS Technology Improve Group Decision Performance For End Users?: An Experimental Study", *Journal of End User Computing*, Volume: 7, Issue: 2, Spring 1995, p: 3-10

Haskin, David, "Brainstorming Software", *Computer Shopper*

Huber, G. P., *Managerial Decision Making*, Scott, Foresman, 1980

Institute for Operations Research and Management Science Home page, http://www.informs.org/

Khazanchi, D., "Evaluating Decision Support Systems: A Dielectric Perspective", Proceedings of the Twenty-Fourth Annual Hawaii International Conference on System Sciences (Cat. No.91TH0350-9), Vol.: 3, p. 90-7

Komoski, P. Kenneth; Plotnick, Eric, "Seven Steps to Responsible Software Selection", ERIC Clearinghouse on Information and Technology, Syracuse, NY, 1995

LaPlante, Alice, "'90s Style Brainstorming", *Forbes*, Oct. 25, 1993, p: 44-61

Pearson, J Michael; Shim, J P, "An Empirical Investigation Into DSS Structures And Environments", *Decision Support Systems*, Volume: 13, Issue: 2, Feb. 1995, p: 141

Rapoza, Jim, "Decision-Making Duo Gives Businesses Choices", *PC Week*, December 4, 1995

Rathnam, Sukumar; Mannino, Michael V, "Tools For Building The Human-Computer Interface Of A Decision Support System", *Decision Support Systems*, Volume: 13, Issue: 1, Jan 1995 p: 35-59

Savage, Sam, "Weighing the Pros and Cons of Decision Technology in Spreadsheets", *OR/MS Today*, Volume 24, Number 1, February 1997

Schimmelpenninck, Sander, "Spreadsheet Add-In Weighs Up Pros, Cons", *Computing Canada*, Volume: 20, Issue: 23, Nov. 9, 1994, p: 32-33

Seiter, Charles, "Decision Analysis 2.5", *MacWorld*, November 1994

Sherman, Erik, "Decision-Support Software Helps Managers Customize", *MAC Week*, July 29, 1996 / Volume 10 Number 29

Twigg, Carol A., "It's the Student, Stupid!", *Educom Review*, Volume 31, Number 3, May/June 1996

Unknown, "Decision Support Software", *OR/MS Today*, Summer 1996

Unknown, "DSS Software Selection", *Information and Management*, Volume: 17, 1989.

Unknown, "Why Technology?", *Educom*, Volume 31, Number 3, May/June 1996

Vanguard Software Home page, Vanguard Software http://www.vanguardsw.com/

Varney, Sarah E, "Decision-support suite ships", *PC Week*, Volume: 11 Issue: 19 May 16, 1994, p: 63

Which & Why Home page, Arlington Software, http://www.arlingsoft.com/ww/,

Young, Lawrence F., *Decision support and Idea Processing Systems*, William C Brown, 1989

APPENDIX A - METHODS FOR DECISION MAKING

There are a number of techniques which have been developed to assist the manager in making decisions. Though we typically solve these problems with the aid of a computer program, they do not necessarily require the use of a computer. These models serve not only to present an answer to a problem but to allow the decision maker to develop an insight into the problem itself by examining various facets of it and by exploring alternative ways of looking at the problem.

When using decision analysis, a problem is broken down into clearly defined components which depict all options, outcomes, inputs and probabilities. These values are quantified thus permitting the evaluation of costs and benefits associated with alternative courses of action. This process does not replace the decision maker with arithmetic, rather, it provides an orderly and more easily understood structure that helps to support the decision maker by providing him with logically sound techniques to support and ensure internal consistency of his judgments.

There are several popular models in use in decision analysis including the decision tree, influence diagram and the analytical hierarchy process.

A. INFLUENCE DIAGRAMS

Among the most basic decision analysis tools is the influence diagram. Influence diagrams consist of blocks which represent decisions, chances and outcomes and the relationship which exists between these events. Figure 27 shows a decision problem concerning how to invest. The influence diagram does not solve the problem but allows the decision maker to visualize the decision and the factors which influence the outcome.

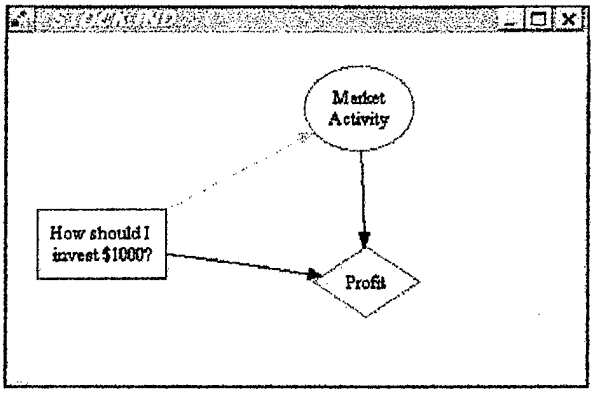

Figure 27 DATA uses influence diagrams to allow the decision maker to formulate the decision problem. In the diagram, blue squares represent decisions, green circles represent chance occurrences and the red diamond represents the outcome. [From Decision Analysis by Tree Age]

B. DECISION TREES

Decision trees offer a way to structure and represent a problem and choose the course of action consistent with certain kinds of objectives. In order to use a decision tree, the decision maker must know, or be able to estimate the possible actions or choices, the cost or value of each action, and how likely each action is. Given this information, the decision tree returns an expected value of each path from which the decision maker will chose the best path.

Decision trees consist of two types of nodes, chance and choice. Chance nodes represent events outside the decision makers control and involve a percentage likelihood that the given event will occur. Choice nodes represent decisions which must be made. Figure 28 shows a decision tree which depicts the investment decision shown as an influence diagram in Figure 27. In this scenario, outcomes (profit) are listed on the right. Decision nodes are shown as blue boxes. There are two choices for the decision maker, to invest in CD's paying 5% or in a risky investment. Chance nodes are shown as green circles with the percentage likelihood of each eventuality shown, as well as the expected value of the overall node. The preferred path based on expected value is shown in magenta.

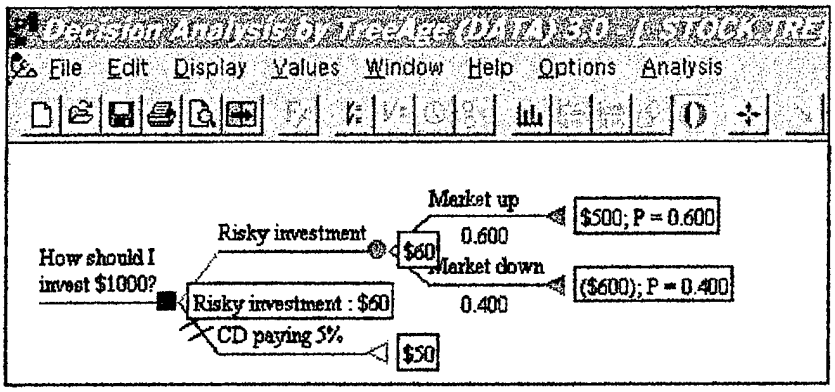

Figure 28 This decision tree was generated by DATA and shows a decision to drill for oil. [From Decision Analysis by Tree Age]

Decision trees represent problems at an elemental detail level. Problem can quickly grow to hundreds of nodes.

C. MULTI-CRITERIA DECISION MAKING

Multiple-criteria decision making is applicable to decision problems with a decision maker considering multiple alternatives whose objective function values are known with certainty. Consider the following example. You are choosing between two fighter aircraft, the details of which are shown in Table 7.

	Aircraft A	Aircraft B
Price	$17 million	$19 million
Speed	Mach 1.7	Mach 1.8
Range	800 miles	700 miles

Table 7

In this example, the decision maker must decide if aircraft A, which has a lower price but lower performance figures, is better than aircraft B, a higher performance but more expensive aircraft. The decision support system must transform the scores of the different criteria to comparable values or scales which may or may not be linear.

There are several issues to consider. In this example, the criteria are on different scales. Is a speed of mach 1.7 and a range of 800 miles better or worse than a speed of mach 1.8 and a range of 700 miles? In order to evaluate this situation, we need to trans-

form these scores to comparable values or scales. Another problem arises from the fact that even for individual criteria, the utility functions may not be linear. Is the 100 mile difference between a range of 700 and 800 miles as important as the difference between 300 and 400 miles? In order to resolve these issues, it is necessary assign new scales of measurement using some upper and lower bound and then evaluate the weighted scores for each alternative.

D. ANALYTICAL HIERARCHY PROCESS (AHP)

The analytical hierarchy process is a theory of measurement for dealing with decision problems characterized by multiple objectives, criteria and multiple alternatives. The AHP method focuses on preparing a hierarchical design and conducting an evaluation which emphasizes the expertise of the decision maker given a set of alternatives. In the design phase, the decision maker breaks the problem into constituent parts and develops a hierarchy of objectives, criteria and alternatives. In the aircraft example the objective is to procure the best aircraft for the dollar. The criteria include speed, range and a host of other features not shown. Our alternatives include aircraft A and B. In the evaluation phase, the decision maker rates the alternatives on each criteria and develops relative weights using pairwise comparison. Each element in a level is compared in relative terms for each criteria just above the element. The output from this is a relative scale of measurements of the priorities or weights of elements. Figure 29 29 shows one program's approach to developing a solution to our aircraft problem using AHP.

There are several considerations involved in using AHP including what kind of hierarchy should be used and what should go into each level. The designer must consider the scale and measurements to use. Inconsistencies can develop due to the use of relative scales or absolute measurements (e.g., good, average, poor).

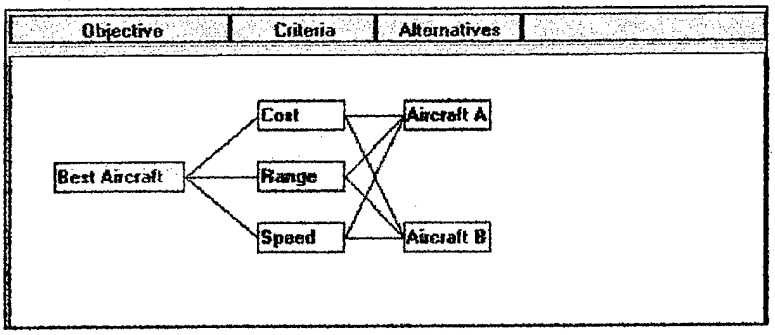

Figure 29 Criterium Decision Plus utilizes AHP in decision making. [From Decision Plus by Criterium]

E. SIMPLE MULTIATTRIBUTE UTILITY TECHNIQUE (SMART)

Another ranking technique is the Simple Multiattribute Utility Technique (SMART) which is available in Decision Plus and LDW.

Before the user can synthesize the contributions of criteria with differing scale, the decision model must provide a method that allows the user to handle model scales on an equal footing. For example, in the aircraft selection problem above, the decision maker needs to assign comparable scales to speed and range. In both AHP and SMART, the model technique itself handles this problem. This is achieved by normalization, where all scales are converted to a common internal scale that takes a value between 0 and 1.

In AHP, to get the effective importance of a subcriterion, the program takes its user-given score divided by the sum of the scores of all the other subcriteria of the common criterion. This guarantees that no matter what the original score, all weights will fall between 0 and 1.

This is a very simple and effective method that allows integration of units that are completely different. However, it is clearly a relative judgment method. How a particular alternative scores in the model depends on what other alternatives are being considered. For instance, in AHP if you created a model for one set of alternatives, adding a new alternative later will change the scores of the original alternatives, sometimes in surprising ways.

SMART does not use a relative method for scaling units to a standard scale (from 0 to 1). Instead, the user can define their own method for doing this using a value function. A value function allows decision makers to explicitly define how each value on the scale is transformed to the common model scale.

F. UTILITY THEORY

Utility theory offers an approach for making and understanding decisions. It is based on a subjective view of how valuable certain payoffs are when outcomes are either certain or probabilistic and is a measure of the worth one attaches to an outcome or situation. Utility is subjective and may change over time. Rational decision makers will attempt to maximize utility. Utility functions are frequently expressed graphically. Figure 30 shows the utility value for given speeds in our aircraft problem.

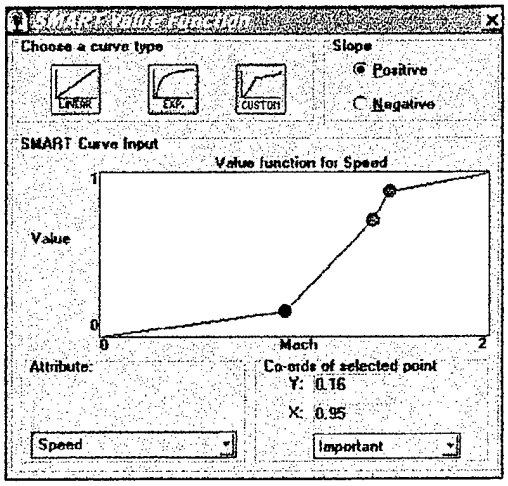

Figure 30 Criterium uses a graphical approach to assigning utility value. The user uses the mouse to adjust the curve to the appropriate utility value. [From Decision Plus by Criterium]

In this example, utility value remains relatively low until the plane's speed reaches mach one. A fighter aircraft with a speed below mach one has little utility regardless if the speed is mach .1 or mach .5. The utility increases rapidly up until about mach 1.5. Above this, little additional utility need be assigned because the plane is already faster than most of our competitors. By converting a raw data value, mach 0 to mach 2, to a utility score

of zero to one, we can now use this number can now be used in comparison with other factors involved in our decision.

G. WEIGHTING AND UTILITY FUNCTIONS

All DSS allow the decision maker to assign weights to the criteria being measured. Most use a graphical approach utilizing some form of pairwise comparison which allows the user to rank their preference of criteria over another. Figure 31 shows one example where the user uses slide bars to rank each feature on a ten point scale.

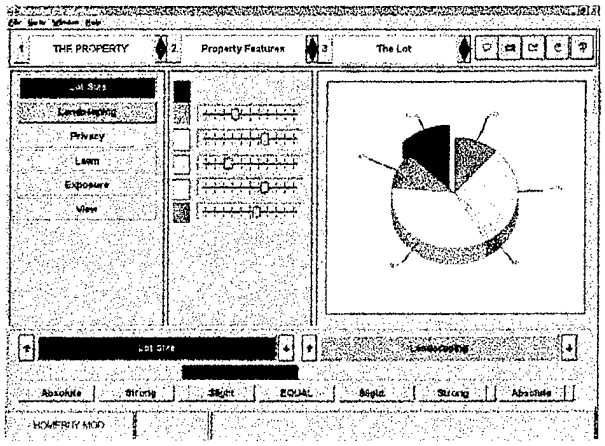

Figure 31 Which and Why uses a graphical method to assign values to preferences. In this example, the user uses slide bars to rank his preference for one feature over another. The pie chart shows the overall preference weights. [From Which and Why by Arlington Software]

H. MONTE CARLO SIMULATION

Monte Carlo simulation is used for modeling uncertainty to help manage risk and simulate complex systems. Risk is generally thought of as either the chance of some unfortunate event happening or as the volatility of a key performance measure such as profits. Decision trees provide an excellent method of planning uncertain actions to take in response to events. Monte Carlo simulations, on the other hand, are best for modeling uncertainty and volatility.

Monte Carlo simulation allows the user to replace uncertain quantities in the model with the results of a number of random trials and then see how that uncertainty affects the

results. Like decision trees, Monte Carlo simulations result in an expected value that aids in choosing the most attractive course of action. They also provide information about the range of outcomes such as best- and worst-case, probability of reaching specific targets, most likely outcomes, etc.

One advantage of Monte Carlo simulation is that it is easy to apply. When combining several uncertain values, determining the uncertainty on the result can be very complex. For example, when adding two uncertain values, the uncertainty on the result is somewhat less that the sum of the original uncertainties. Using Monte Carlo simulation, this and similar effects are handled automatically so the user doesn't need to know much about statistics to get accurate results.

APPENDIX B - TECHNICAL FEATURES SUMMARY

Product	Vendor	Win 95	Win 3.x	DOS	RAM Required	Objectives Trade-off (1)	Analysis of uncertainty (2)	Probabilistic Dependecies (3)	Risk Aversion	Sequential decision making	All applications - one model (4)	Commercial	Educational
@RISK	Palisade Corp.	y	y	n	4 MB	y	y	y	y	y	y	$395	call
AliahTHINK!	Aliah Inc.	y	y	y	8 MB	y	y	y	y	y	y	$2050	N/A
Analytica	Lumina Decision Systems	n	n	n	4 MB	y	y	y	y	y	y	$695	$100
BestFit	Palisade Corp.	y	y	n	2 MB	n	y	n	n	n	n	$299	call
CADET	AT&T	y	y	n	4 MB	n	y	y	y	y	n	$500	N/A
Criterium Decision Plus	InfoHarvest Inc.	y	y	n	8 MB	y	y	y	n	n	n	$495	$295
Crystal Ball	Decisioneering Inc.	y	y	n	4 MB	y	y	y	y	n	n	$395	$69
DPL	Applied Decision Analysis	y	y	n	2 MB	y	y	y	y	y	y	$495-$995	$53.50-$107
DecideRight for Windows	Avantos Performance Systems Inc.	y	y	n	8 MB	y	n	n	n	n	n	$149	N/A
Decision Analysis by TreeAge (DATA)	TreeAge Software Inc.	y	y	n	4 MB	y	y	y	y	y	y	$450	$225
Decision Explorer	Banxia Software Ltd.	y	y	n	4 MB	y	y	y	y	y	y	call	call
ELECTRE III-IV	Lamsade-Ura 0825	n	y	n	4 MB	n	y	n	n	n	n	$1,400	$560
EQUITY for	Krysalis	y	y	n	4 MB	y	n	n	n	n	n	$1,350	$225

Windows	Ltd.												
Expert Choice Professional	Expert Choice Inc.	y	y	n	8 MB	y	y	y	y	y	y	$595	$416.50
HIVIEW for Windows	Krysalis Ltd.	n	y	n	4 MB	y	n	n	n	n	n	$900	$145
HIPRE 3+	Santa Monica Software	y	y	y	4 MB	y	y	n	y	y	n	$295	$295
Logical Decisions	Logical Decisions	y	y	n	4 MB	y	y	n	y	n	y	$395	$295
MAPPAC and PRAGMA	B. Matarazzo	n	y	y	4 MB	y	n	n	n	n	n	$800	$600
POLICY PC	Executive Decision Services	n	n	y	512 KB	y	n	n	y	n	n	$500	$100
Quick Compare	Blue Blazer Computing	n	y	y	200 KB	y	y	y	n	n	y	$34.95	call
RiskSim (for Excel)	Decision Support Services	y	y	n	4 MB	n	y	n	n	n	n	$29-$300	call
SOS P/G%	Decision Aids Inc.	n	n	y	512 KB	y	y	y	y	y	y	$50	$50
Sensit (for Excel)	Decision Support Services	y	y	n	4 MB	n	n	n	n	n	n	$29-$300	call
Sensitivity/Supertree	Strategic Decisions Group - Decision Systems	y	y	y	8 MB	y	y	y	y	y	y	$1500	$75
Team Expert Choice	Expert Choice Inc.	y	y	n	8 MB	y	y	y	y	y	y	$13,295	$9,306
TopRank	Palisade Corp.	y	y	n	4 MB	y	y	y	y	y	y	$249-$395	call

TreePlan (for Excel)	Decision Support Services	y	y	n	4 MB	n	y	n	y	y	n	$29-$300	call
VISA	Visual Thinking International Ltd.	y	y	n	8 MB	y	y	y	n	n	n	$395	University site license - $999
Which & Why V4.0	Arlington Software Corp.	y	y	y	4 MB	y	y	n	y	y	y	$349	$249

Explanation of Questions:

(1) Are there trade-offs amongst multiple objectives?

(2) Is there representation/analysis of uncertainty?

(3) Is there representation/analysis of probabilistic dependencies?

(4) Are all of the above available in one model?

[From OR/MS Today 1996]

SPREADSHEET ADD-INS

Product	Publisher	Type of Product (1)						Spread-sheets			Limitations		Price		Product Description
		Sim	Opt	For	Dec	Fin	Link	EX	123	QP	COM.	EDU.	COM.	EDU.	
@nalyst	Tech Hackers Inc.	N	N	Y	N	Y	Y	Y	N	N	Based on systems resources	A special program is avail-able	$295-$2,500	N	@nalyst provides so-phisticated analytics functions for bonds, options, mbs, business dates and amortiza-tion. Also available as c-subroutine libraries.
@Risk	Palisade Corporatio n	Y	N	N	N	N	N	Y	Y	N	Iterations: memory dep.; cor-relation: spreadshe et dep.	Same as commer cial	$395	call	@Risk is the Risk Analysis add-in for Ex-cel and Lotus 1-2-3. @Risk adds the power of Monte Carlo simu-lation to any spread-sheet model. Gener-ates graphs and de-tailed statistical reports
AXA	Sunset Software Tech.	N	Y	N	N	N	N	Y	N	N	Model size limited by available memory	500 rows by 1,000 columns	call	call	AXA solves linear and integer linear pro-gramming models. The AXA engine is a dy-namic link library available for use by other programming languages like Visual Basic, C++ and For-tran.
BestFit	Palisade Corporatio n	N	N	N	N	N	N	N	N	N	Up to 30,000 data points or pairs	Same as commer cial	$299	call	BestFit® is distribution fitting solution for Win-dows. BestFit finds the statistical distribution that best fits any data set up to 30,000 points. Results can be used in @Risk.
Crystal Ball	Decisione ering	Y	N	N	Y	N	N	Y	Y	N	Unlimited iterations	Same as commer	$395	$129	Crystal Ball is a lead-ing Monte Carlo simu-

												cial			lation add-in for Excel and Lotus 1-2 that performs forecasting and risk analysis for spreadsheet-based modeling.
DataImport®	Spalding Software	N	N	N	N	N	N	Y	Y	Y	Maximum of 2,048 characters per line	Same as commercial	$189	$189	DataImport pulls data from even complex multi-level reports into the native formats of Excel, Lotus 1-2-3, Quattro Pro, Access, etc. The user selects the specific data, needed by defining inclusion/exclusion criteria.
DPL	Applied Decision Analysis	N	N	N	Y	N	N	Y	Y	N	No hard wired constraints	Speed reduced to limit models to around 2k endpoints	$495-$995	$50-$100	DPL is a complete decision analysis package that links influence diagrams decision trees to spreadsheet models. Extensive graphical outputs include decision policies, risk profiles and sensitivity analysis.
Evolver	Palisade Corporation	N	Y	N	N	N	N	Y	N	N	All components in optimization must be on single Excel sheet.	Same as commercial	$ 349	call	Evolver™ uses innovative genetic algorithm (GA) technology to quickly solve complex optimization problems in virtually any type of problem that can be modeled in an Excel spreadsheet.
Exotic Options Simulator	Montgomery Investment Technolog	Y	N	N	N	Y	Y	Y	N	N	Requires @Risk 3.5 for Excel.	Same as commercial	$795-$995	call	Pricing of exotic, path dependent options using Monte Carlo simulations techniques.

	y Inc.														Prices average, barrier and lookback exotics and plain vanilla options.
Exotics @nalyst	Tech Hackers Inc.	Y	N	N	N	Y	Y	Y	N	N	Based on systems resources	A special program is available; contact company	$995-$3,700	N	Exotics @nalyst is available in three modules: Asian/Lookback; Binary/Barrier and Basket/Chooser. Industry-accepted models are used for pricing, gap, best-of-two securities and exchange.
Fin Tools	Montgomery Investment Technology Inc.	Y	N	Y	N	Y	Y	Y	Y	N	N	Limited time licensing	call	call	A suite of spread sheet add-ins and development tools for options analysis and simulation; bond analysis and pricing; and commodity price forecasting, especially electricity.
Insight	Duxbury Press	Y	Y	Y	Y	N	N	Y	N	N	M.C. Simulation: 5,000 iterations, 5 output cells; Trees: Ltd. by spreadsheet size	N	$50	$25	A package of easy-to-use analytical tools designed for teaching and quick back of the spreadsheet modeling. Includes examples that display fundamental analytical concepts.
Precision Tree	Palisade Corporation	N	N	N	Y	N	N	Y	N	N	N	N	$495-$795	call	Precision Tree™ is the decision analysis link to Excel. Use influence diagrams to see the relationships between components of a problem then add decision trees to see the sequence of events.

RISKview	Palisade Corporation	N	N	N	N	N	N	N	N	N	N	N	$79-$149	call	RISKview™ is the distribution viewing companion to @RISK, @Risk for Project, @RISK for TopRank or BestFit. It is a powerful tool for viewing, assessing and creating probability distributions.
TopRank	Palisade Corporation	N	N	N	N	N	N	Y	Y	N	Pro: Unltd.; Stnd.: Ltd. Multi-way analysis, no @Risk function	Same as commercial	$249 - $395	call	TopRank® is the What-If add-in for Excel and Lotus 1-2-3. TopRank determines which values affects your bottom line the most and ranks them in order of importance.
Weighted Decision Object	InfoHarvest Inc.-	N	N	N	Y	N	N	Y	N	N	Limited to 100 criteria	N	$299	N	The WDO is an OLE object that allows the user, using VBA to submit tables of data to a Criterium DecisionPlus Multi-criteria model and obtain decision scores and pass/fail results.
What's Best!	LINDO Systems Inc.	N	Y	N	N	N	N	Y	Y	N	Various capacity versions available from 1,600 variables to unlimited.	Student ver. ltd. to 400 variables, larger capacity versions available at ed. discounts	from $695	from $25	What's Best! solves large-scale linear, nonlinear and integer models in Excel or 1-2-3. It's powerful enough to handle the toughest problems and ideal providing models to managers or clients.

Key to abbreviated column heads:

Type of Product:
Sim. = Simulation
Opt. = Optimization
For. = Forecasting
Dec. = Decision analysis
Fin. = Financial engineering
Links = Links to analytic engines
Spread-sheets:
Exc = Excel
123 = Lotus
Qp = Quattro Pro
Limitations / Price
Com. = Commercial
Edu. = Education
Note: y indicates a positive response, n indicates either a negative response or no response
[From ORMS Today, Feb. 97]

TECHNICAL FEATURE DETAILS

Feature	AliahThink 2.11 (Trial)	Criterium Decision Plus 2.0.01 (Student)	DPL (Demo)	Decide Right 1.2	Decision Pro 2.0.5-16 (Demo)	DATA 3.0	Expert Choice 9.0	LDW 4.004 (Student)	@Risk Win95	Which and Why 3.0
Technical										
OS[1]	Win95, Win 3.x, Mac	Win95, Win 3.x	Win95, Win 3.x	Win95, Win 3.x	Win95, Win 3.x	Win95, Win 3.x	Win95, Win 3.x	Win95, Win 3.x	Win95, Win 3.x	Win95, Win 3.x, Mac
Memory	8	8	2	8	4	4	8	4	4	4
Security	N	N	N	N	N	N	N	N	N	N
Group Support	Y	N	N	N	N	N	N[2]	N	N	Y
Macros/Programming	Y[3]	N	N	N	Y[4]	N	N	N	Y	N
Problem Type										
DM Under Uncertainty			Y		Y	Y				
Multi-Criteria	Y	Y		Y			Y	Y		Y
User Interface										
User interface remarks		Traditional AHP configuration usefule to educators.		Program guides user through decision problem.					Well known spreadsheet interface minimizes time to learn.	
Dialog M = Menu F = Function Keys	M, F	M	M	M, F	M	M	M	M	M, F	M
Brainstorming	Y	Y	N	Y	N	N	N	N	NA	Y

[1] Few of the programs are written for Windows 95.

[2] A group version is available separately.

[3] User can create custom interface.

[4] User can create custom interface.

Data values R = Relative A = Absolute S = Statistical	A,R	A,R, S	A	A,R	A	A	A,R	A,R,S	A	R
Utility functions	N	Y	NA	N	NA	NA	N	Y	NA	N
Output										
Output Remarks	Wide variety of output graphs.	Dynamic sensitivity useful for demonstrations.		Will export plain language report to word processor.				Wide variety of outputs.		
Bar Chart	Y	Y	NA	Y	NA	NA	Y	Y	NA	Y
Scatter diagram	N	Y	N	N	N	N	Y	Y	Y	Y
Spider (Radar) Chart	Y	N	N	N	N	N	N	N	Y	N
Probability distribution (Uncertainty)	N	Y	Y	N	Y	Y	N	Y	Y	N
Sensitivity (D)ynamic	Y (D)	Y (D)	Y	Y[5]	Y	Y	Y	Y (D)	Y	Y
Export to other applications	N	N	Y	Y[6]	N	Y	Y	Y	Y	N
Data Management										
DBMS Functions	N	N	N	N	N	N	N	N	N	N
Data import / export (S)preadsheet (D)atabase (T)ext	S, D, T	S, T	Y[7]	N	T	N	S, T	S, T, D	S, D, T	S, D, T
Model Management										

[5] Shows sensitivity on the input screen vice as an output graph.

[6] Will create a text and graphics report for use in word processor.

[7] Can utilize spreadsheet for required math functions.

Remarks		Traditional model construction is easy to use and good for demonstration or classroom.		Simple model is easy to construct and evaluate.		Traditional model construction is easy to use and good for demonstration or classroom.		Widest variety of comparison methods.		
Version support	Y	N	Y	Y	Y	Y	N	N	N	N
Decision Tree			Y		Y	Y				
Influence Diagram			Y		N	Y				
AHP	Y	Y		N[8]			Y	Y		N[9]
SMART	N	Y		N			N	N		N
Goal seek	N	N		N	Y	N	N	N	Y	N
Simulation	N	N	Y	N	Y	Y	N	Y	Y	N
Support										
	Excellent tutorial make it easy to learn. Good online help.	Excellent help features make it easy to use this program.	Limited help makes this powerful program well suited to the experienced user.	Help features walk the user through setting up decision problems.		Excellent help provides a virtual course in decision making.		One of the more powerful programs. Limited help makes this a program well suited for experienced users.	Cited by some for its spreadsheet interface. An excellent tool for enhancing insight provided by a spreadsheets.	A powerful program with excellent help features.
OnlineTutorial	Y[10]	N	N	N	Y	N	Y	N	Y[11]	N

[8] Uses proprietary method.

[9] Uses proprietary method.

[10] Aliah also has Web based tutorial.

[11] Excellent demonstration CD ROM available.

Help Features (P)rogram Help (D)ecision Making In-sight (B)uttons on screens	P,B	P, B, D	P	P, B	P, B, D	P, B, D	P,D	P, D	P, B	P, D, B
Web site (P)rogram information (D)SS Information (T)rial versions	D,T	P, T, D	N	P, T	P,T	P, T	P, D,T	P, T	D, T	P, T, D

APPENDIX C - EDUCATOR SURVEY

Dear Sir,

I am a graduate student in the Information Technology Management program at the Naval Postgraduate School in Monterey, California. Along with Professor Hemant Bhargava and Professor Sridhar, I am preparing a Master's thesis titled "An Analysis of Software for Decision Analysis".

As you may know, there are now various commercial "DSS Generators" for working with decision analysis methods such as decision trees and multicriteria decision making. Broadly, we have classified such software into 3 categories of use: production (development of real DSS applications), demonstration (development of prototype applications) and education (in DSS methods and/or software).

The focus of my thesis is to examine the feature set required to support DSS work in the above 3 categories, to compare this against feature sets available in leading commercial systems, and to develop general recommendations for selecting software for the 3 categories of use.

In order to determine which characteristics of a DSS package are most significant in educational use, we have developed the following list of features we feel would be important to educators. However, I would greatly appreciate it if you could take a few minutes to review the list and answer the questions posed. In addition, I would appreciate any other input you may have regarding what is important to you when selecting DSS software for use in your classes.

1. Basic questions

a. At what level do you instruct DSS [Undergrad, Graduate, Continuing education programs, Multiple]:

b. Which DSS packages have you used before in the classroom? With regards to the questions shown below, what features attracted you to the packages you used?

c. Which DSS packages have you rejected for use in the classroom? Why?

In EACH section below you have a total of 100 points which may be distributed among the various choices. Allocate more points to the features you consider most important. The sum of points allocated IN EACH SECTION should equal 100.

2. In your courses, what is your emphasis with regards to using DSS software (allocate 100 points between each of the following two items):

a. How to use DSS software _____

b. Using DSS software as support for teaching DSS _____

3. Software selection. How important are the following issues when selecting software to use (allocate 100 points between each of the following five items):

a. Length of time to required for student to learn _____

b. Ease of use _____

c. Multiple platform support (MAC, DOS) _____

d. Ability to use on network _____

e. Cost of acquiring package _____

f. Please give any other remarks related to what is important to you in selecting software:

4. Application related questions. Which available features are important (allocate 100 points between each of the following ten items):

User Interface:

a. Mouse and windows support _____

b. Input characteristics _____

c. Output representation (reports, graphs) _____

Data handling features

d. DBMS functions _____

e. Version management _____

f. Data import and export capability _____

g. Models (A variety of models on a single package)

h. Ability to build large, complex models _____

i. Version support _____

j. Model export to other applications _____

k. Availability of statistical functions _____

l. Please give any other remarks related to what is important to you in regarding application design:

5. Training related issues. Which of the following features related to using the program are important (allocate 100 points between each of the following four items):

a. Sample exercises are provided ____

b. Computer based tutorials are provided ____

c. Results are explained ____

d. The program provides tips and insight _____

e. Please give any other remarks related to what is important:

6. How important is it that the program support the following DSS considerations (allocate 100 points between each of the following five items):

a. Modeling uncertainty _____

b. Subjectivity _____

c. Utility functions _____

d. Risk _____

e. Sensitivity analysis _____

f. What other items are important to you regarding features of DSS:

7. Support. How important are the following support related issues. (allocate 100 points between each of the following six items):

a. FAQ file online _____

b. Discussion group availability _____

c. Mail lists availability _____

d. Technical support via phone or email_____

e. Level of local support available _____

f. Is there online documentation _____

g. Are there other support features that are important to you:

8. Please take a moment and think about your use of DSS software in the classroom. Are there any other considerations you would like to share:

APPENDIX D - VENDOR SURVEY

Dear Sir,

I am a graduate student in the Information Technology Management program at the Naval Postgraduate School in Monterey, California. Along with Professor Hemant Bhargava and Professor Sridhar, I am preparing a Master's thesis titled "An Analysis of Software for Decision Analysis".

As you know, there are now various commercial "DSS Generators" for working with decision analysis methods such as decision trees and multicriteria decision making. Broadly, we have classified such software into 3 categories of use: production (development of real DSS applications), demonstration (development of prototype applications) and education (in DSS methods and/or software).

The focus of my thesis is to examine the feature set required to support DSS work in the above 3 categories, to compare this against feature sets available in leading commercial systems, and to develop general recommendations for selecting software for the 3 categories of use.

In order to determine which characteristics of a DSS package are most significant to users of such programs, we have developed the following list of features we feel are important to all users of DSS software. However, I would greatly appreciate it if you could take a few minutes to review the list and answer the questions posed from the perspective of the user as you see his needs. Any will be used for research purposes only. You confidentiality will be ensured

1. Basic questions

How many copies of your program have you sold?

How long has your product been on the market?

c. As well as producing software, do you offer consulting services?

In EACH section below you have a total of 100 points which may be distributed among the various choices. Allocate more points to the features you consider most important. The sum of points allocated IN EACH SECTION should equal 100.

2. In designing your software, who do you see as your primary intended user (allocate 100 points between each of the following four items):

a. Education _____

Production (Strategic use) _____

Production (lower level use) _____

d. Demonstration _____

3. Software selection. When designing your software, how important do you feel the following issues are to your users when they select software (allocate 100 points between each of the following five items):

Length of time to required for user to learn _____

b. Ease of use _____

c. Multiple platform support (MAC, DOS) _____

d. Ability to use on network _____

e. Cost of acquiring package _____

f. Power (variety of features, outputs, size of models) _____

g. Please give any other remarks related to why your users select a particular package:

4. Application related questions. When designing your product, which available features do you feel are most important to your users (allocate 100 points between each of the following ten items):

User Interface:

a. Mouse and windows support _____

b. Input characteristics _____

c. Output representation (reports, graphs) _____

Data handling features

d. DBMS functions _____

e. Version management _____

f. Data import and export capability _____

Models

g. Ability to build large, complex models _____

h. Model version support _____

i. Model export to other applications _____

j. Availability of statistical functions _____

k. Please give any other remarks related to what is important to you in regarding application design:

5. Training related issues. When designing your product, which of the following features related to using the program are important to your users (allocate 100 points between each of the following four items):

a. Sample exercises are provided ____

b. Computer based tutorials are provided ____

c. Results are explained ____

e. The program provides tips and insight _____

e. Please give any other remarks related to what is important with regards to training:

6. When designing your product, how important is it to your users that the program support the following DSS considerations (allocate 100 points between each of the following five items):

a. Modeling uncertainty _____

b. Subjectivity _____

c. Utility functions _____

d. Risk _____

e. Sensitivity analysis _____

Availability of math functions to document decisions _____

g. What other items are important to you regarding features of DSS:

7. Support. How important are the following support related issues to your users. (allocate 100 points between each of the following six items):

a. FAQ file online _____

b. Discussion group availability _____

c. Mail lists availability _____

d. Technical support via phone or email_____

e. Level of local support available _____

f. Is there online documentation _____

g. Are there other support features that are important to you:

Please take a moment and think about other considerations when designing DSS software. Are there any other issues you would like to share:

9. If you have the names and email addresses of any corporate users who you believe would be willing to answer questions such as the ones in this survey I would appreciate your sharing them with me?

APPENDIX E - PRODUCTION USERS SURVEY

Dear Sir,

I am a graduate student in the Information Technology Management program at the Naval Postgraduate School in Monterey, California. Along with Professor Hemant Bhargava and Professor Sridhar, I am preparing a Master's thesis titled "An Analysis of Software for Decision Analysis".

As you know, there are now various commercial "DSS Generators" for working with decision analysis methods such as decision trees and multicriteria decision making. Broadly, we have classified such software into 3 categories of use: production (development of real DSS applications), demonstration (development of prototype applications) and education (in DSS methods and/or software).

The focus of my thesis is to examine the feature set required to support DSS work in the above 3 categories, to compare this against feature sets available in leading commercial systems, and to develop general recommendations for selecting software for the 3 categories of use.

In order to determine which characteristics of a DSS package are most significant to users of such programs, we have developed the following list of features we feel are important to all users of DSS software. However, I would greatly appreciate it if you could take a few minutes to review the list and answer the questions posed from the perspective of the user. Any will be used for research purposes only. You confidentiality will be ensured

1. Basic questions

a. Which DSS packages have you used before in the classroom? With regards to the questions shown below, what features attracted you to the packages you used?

b. Which DSS packages have you rejected for use in the classroom? Why?

In EACH section below you have a total of 100 points which may be distributed among the various choices. Allocate more points to the features you consider most important. The sum of points allocated IN EACH SECTION should equal 100.

2. What do you see as the primary intended purpose of DSS software (allocate 100 points between each of the following four items):

a. Production (Strategic use) _____

b. Production (lower level use) _____

3. Software selection. When selecting software, how important do you feel the following issues are (allocate 100 points between each of the following five items):

a. Length of time to required for user to learn

b. Ease of use

c. Multiple platform support (MAC, DOS)

d. Ability to use on network

e. Cost of acquiring package

f. Power (variety of features, outputs, size of models)

g. Please give any other remarks related to why your users select a particular package:

4. Application related questions. Which available features do you feel are most important (allocate 100 points between each of the following ten items):

User Interface:

a. Mouse and windows support _____

b. Input characteristics _____

c. Output representation (reports, graphs) _____

Data handling features

d. DBMS functions _____

e. Version management _____

f. Data import and export capability _____

Models

g. Ability to build large, complex models _____

h. Model version support _____

i. Model export to other applications _____

j. Availability of statistical functions _____

k. Please give any other remarks related to what is important to you in regarding application design:

5. Training related issues. Which of the following features related to using the program are important (allocate 100 points between each of the following four items):

a. Sample exercises are provided ____

b. Computer based tutorials are provided ____

c. Results are explained ____

e. The program provides tips and insight _____

e. Please give any other remarks related to what is important with regards to training:

6. How important is it that the program support the following considerations (allocate 100 points between each of the following five items):

a. Modeling uncertainty _____

b. Subjectivity _____

c. Utility functions _____

d. Risk _____

e. Sensitivity analysis _____

f. Availability of math functions to document decisions ____

g. What other items are important to you regarding features of DSS:

7. Support. How important are the following support related issues (allocate 100 points between each of the following six items):

a. FAQ file online _____

b. Discussion group availability _____

c. Mail lists availability _____

d. Technical support via phone or email_____

e. Level of local support available _____

f. Is there online documentation _____

g. Are there other support features that are important to you:

8. Please take a moment and think about other considerations when selecting or using DSS software. Are there any other issues you would like to share:

9. If you have the names and email addresses of any corporate users who you believe would be willing to answer questions such as the ones in this survey I would appreciate your sharing them with me?

APPENDIX F - SURVEY RESPONSES - EDUCATORS

Question 1 and 2 Basic questions

1 a. At what level do you instruct DSS [Undergrad, Graduate, Continuing education programs, Multiple]:

b. Which DSS packages have you used before in the classroom? With regards to the questions shown below, what features attracted you to the packages you used?

c. Which DSS packages have you rejected for use in the classroom? Why?

In EACH section below you have a total of 100 points which may be distributed among the various choices. Allocate more points to the features you consider most important. The sum of points allocated IN EACH SECTION should equal 100.

2. In your courses, what is your emphasis with regards to using DSS software (allocate 100 points between each of the following two items):

a. How to use DSS software

b. Using DSS software as support for teaching DSS

1.a	1.b	1.c	2.a	2.b
Both	Excel, 'home-made' MCDM written in Turbo Prolog VPExpert, NexpertObject, Knowledge-Pro - for postgrads	NexpertObject - too hard to learn and get access to, QSB - old, user unfriendly system, CMMS from Erikson&Hall book - too restrictive, DOS based.	10	90
Grad	Lotus, SAS	Packages that became obsolete	60	40
Grad	Excel (LP, MIP), IThink (dynamic modeling), several hypermedia system (where I developed my own DSS generator		20	80
Undergrad	Expert Choice, Exsys, Group Systems, Management Decision Assistant, spreadsheets	I've rejected other packages primarily for cost reasons	35	65
Grad	Excel. Easy to use known interface. Oracle express. Exclusive packages	Oracle express. Too expensive	60	40
Undergrad	ubiquity and friendliness	Sigma - not common software	90	10
Both	spreadsheet, mainly (MS Excel) comprehensive, cheap, can illustrate most DSS concepts.	Most specialized packages: expense, difficulty to learn.	70	30
Grad	Demos (currently called Analytica)		10	90
Grad	IFPS, VPExpert Light learning curve. Build models quickly. sensitivity analysis. uncertainty	More industrial strength expert systems. To hard to learn in time available	80	20
Grad	DPL, Criterium, Expert Choice	The most important features are cost and core functionality.	50	50
Both			20	80
Both	ESS		100	0
Both	SSS. GAMS	SLAM II. Too much time to teach technicalities which have no instructive value	5	95
Both	Doesn't believe you can package DSS. Must build in context of its organizational use.	Delphi	40	60
		Average	**50.4**	**49.6**
		Standard Deviation	**31.3**	**31.3**

Question 3

Software selection. How important are the following issues when selecting software to use

3.a	3.b	3.c	3.d	3.e	3. Other	3.f
a. Length of time to required to learn	Ease of use	Multiple platform support	Ability to use on network	Cost of acquiring package		
30	30	10	10	20		I'd like students to use software that might be useful for their real life work, not just theoretical 'toys
30	30	0	20	20		
50	10	0	0	0	40	
20	25	0	15	40		
10	30	10	20	30		Capacity to export/import data to/from other software or applications. Programming facilities.
20	30	0	0	50		
25	25	10	0	40		
30	40	10	0	20		Support for influence diagrams and Bayesian networks is a must.
35	15	0	25	25		Usefulness for thesis projects
0	30	0	20	50		You may wan to separate these out. Btw, a and b tend to be highly correlated I think cost tends to a go-no go factor. Given two packages are both within cost threshold then ease of use and ease of installation (network use0 become factors.
35	35	0	15	15		
33	33	0	0	33		
80	2	2	1	15		
40	40	0	0	20		
26.5	**27.8**	**3.3**	**10.4**	**28.6**		**Average**
18.7	**10.9**	**4.6**	**9.8**	**14.3**		**Standard Deviation**

Question 4

Application related questions. Which available features are important?

4.a Mouse and windows support	4.b Input characteristics	4.c Output representation	4.d DBMS functions	4.e Version management	4.f Data import and export capability	4.g Variety of models	4.h Ability to build large, complex models	4.I Model version support	4.j Model export to other applications	4.k Availability of statistical functions	4.l Sample exercises are provided
10	5	15	5	5	10	20	5	10	15		The software should be flexible enough to build a DSS (perform what-if, have menus for explanations and reports
13	10	10	10	13	10		10	7	7	10	
40	5	5				50					
15	10	15	15	5	10	10	10	0	5	5	
5	15	15	15	5	10	0	5	5	15	10	Programming facilities
20	20	20	0	0	0	5	0	5	5	25	an intuitive interface
0	0	0	33	0	0	0	33	0	0	33	
10	10	20	3	2	5	0	20	2	8	20	
15	0	15	20	0	0	30	0	0	0	20	
30	0	0	20	0	20	20	0	0	20	20	
20	0	20	0	0	10	0	0	0	50		
25	0	25	0	0	0	0	50	0	0	0	
0	0	0	0	0	0	0	17	0	80	3	
15	15	15	5	0	5	20	20	0	0	5	
16.9	**6.3**	**13.3**	**11.0**	**2.7**	**6.8**	**12.3**	**12.1**	**2.6**	**11.4**	**15.9**	**Average**
11.1	**6.9**	**8.3**	**10.3**	**3.9**	**6.2**	**15.5**	**15.0**	**3.4**	**23.6**	**10.5**	**Standard Deviation**

Question 5

Training related issues. Which of the following features related to using the program are important

5.a	5.b	5.c	5.d	
Sample Exercises provided	Computer based tutorials are provided	Results are explained	The program provides tips and insight	
25	20	15	40	
20	30	30	20	
20	20	20		
40	30	15	15	
30	20	30	20	Practical exercises.
10	70	10	10	
33	33	33		
30	30	10	30	
40	40	10	10	
0	50	0	0	
30	10	50	10	
25	25	25	25	
40	60	0	0	
25.3	**32.1**	**20.3**	**17.2**	**Average**
11.9	**17.2**	**14.2**	**12.3**	**Standard Deviation**

Question 6

How important is it that the program support the following DSS considerations

6.a	6.b	6.c	6.d	6.e	6.f
Modeling uncertainty	Subjectivity	Utility functions	Risk	Sensitivity analysis	
35	10	15	15	25	Knowledge representation and inference mechanisms (for KB-DSS)
25	0	0	25	50	
20	20	20	20	20	
25	15	10	15	30	forecasting, ranking, rating, data aggregation
10	30	10	25	25	
20	20	20	20	20	Distinguishing directly controllable inputs, Distinguishing exogenous data, Distinguishing evaluative criteria
33	33	0	0	33	
40	10	30	10	10	
10	0	20	10	60	
20	20	20	10	30	
20	20	20	20	20	
20	20	20	20	20	
20	20	20	20	20	
23.5	**16.2**	**15.0**	**15.5**	**29.4**	**Average**
8.8	**9.8**	**8.6**	**7.1**	**13.5**	**Standard Deviation**

Question 7

Support. How important are the following support related issues.

t	7.b	7.c	7.d	7.e	7.f	7.g
FAQ file online	Discussion group availability	Mail lists availability	Technical support via phone or email	Level of local support available	Is there online documentation	
15	20	25	15	10	15	Practical tutorials and exercises
20	0	0	20	30	30	
	50	20	0	30	0	
20	20	20	10	10	20	
20	20	10	20	20	10	Newsletters, journals or magazines
0	0	0	20	20	60	
0	25	25	25	25	0	
20	20	10	10	10	30	
10	0	0	40	20	30	
65	0	0	35	0	0	Is there local expertise on campus? This really helps with training issues.
0	0	0	30	40	30	
0	0	0	0	0	100	
0	0	0	0	0	100	
17.0	**14.1**	**10.0**	**20.5**	**19.5**	**20.5**	**Average**
18.4	**15.5**	**10.5**	**13.2**	**12.8**	**34.2**	**Standard Deviation**

APPENDIX G - SURVEY RESPONSES - VENDORS

Question 2

In designing your software, who do you see as your primary intended user

2.a	2.b	2.c	2.d	
Education	Production (Strategic use	Production (lower level use	Demonstration	
25	45	20	10	
15	60	15	10	
0	75	25	0	
25	40	25	10	
15	45	35	5	
16.0	**53.0**	**24.0**	**7.0**	**Average**
10.2	**14.4**	**7.4**	**4.5**	**Standard Deviation**

Question 3

Software selection. When designing your software, how important do you feel the following issues are to your users when they select software

3.a	3.b	3.c	3.d	3.e	3. f	3.g
Length of time to required to learn	Ease of use	Multiple platform support	Ability to use on network	Cost of acquiring package	Power	
25	45	20	5	10	35	In addition to the reasons listed above, users are interested in the completeness and quality of documentation and on-line help, the ability of the software to interface with other software packages (spreadsheets, databases, etc.), the availability of an
20	25	5	25	5	20	
10	25	0	5	15	45	
15	30	10	10	10	30	A lot of our users select Analytica because they like influence diagrams they want a package that can scale up to address substantial models and they do not want to have to either become expert decision
25	30	1	7	7	30	Ease of use. Understandability of the process. Appropriate feedback, sense of control, decisive decision making, formalized decision processing, thinking tool, ability to explain decisions
19.0	**31.0**	**7.2**	**10.4**	**9.4**	**32.0**	**Average**
6.5	**8.2**	**8.2**	**8.4**	**3.8**	**9.1**	**Standard Deviation**

Question 4

Application related questions. When designing your product, which available features do you feel are most important to your users

4.a Mouse and windows support	4.b Input characteristics	4.c Output representation	4.d DBMS functions	4.e Version management	4.f Data import and export capability	4.g Ability to build large, complex models	4.h Model version support	4.i Model export to other applications	4.j Availability of statistical functions	4.k
20	5	20	5	0	10	15	0	15	10	We have endeavored throughout our history to offer extremely intuitive applications that have enough power to satisfy the most sophisticated users. This entails attention to the ease of the user interface, thorough and graphical output, ability to inter
15	5	15	5	5	10	10	15	10	10	
15	20	20	5	5	20	20	5	5	5	
20	0	10	5	5	10	10	5	10	20	Clarity of model structure andinternal documentation. Visual diagram. Sound methods based on well established principles.
20	12	14	8	6	12	8	8	8	4	proportions will change in the future as the ability to link with other systems and programs grows, as well as the sophistication of our target users increases. input/output must become more transparent, our interests are not the same as the academic community - we have no theory to defend, only a need to ensure that client requirements are met as best as possible and a and at the highest technical standard. This means understanding how we can help the user in reaching the decision through the most appropriate mechanism.)
18.0	**8.4**	**15.8**	**5.6**	**4.2**	**12.4**	**12.6**	**6.6**	**9.6**	**9.8**	**Average**
2.7	**7.8**	**4.3**	**1.3**	**2.4**	**4.3**	**4.9**	**5.5**	**3.6**	**6.3**	**Standard Deviation**

Question 5

Training related issues. When designing your product, which of the following features related to using the program are important to your users

5.a	5.b	5.c	5.d	
Sample exercises are provided	Computer based tutorials are provided	Results are explained	The program provides tips and insight	
40	5	40	15	A simple, clear tutorial (contained in our user's manual), with complete reference chapters on more advanced topics, have been consistently praised for teaching people how to use the software successfully.
20	30	30	20	
30	10	35	25	
33	44		22	seminars available.
7	18	40	35	there are a few key elements to trigger the understanding of a user to the process of decision making. hurdle can be overcome often with a few minutes of proper instruction or guidance within the software. The trick is how to achieve this. more sophisticated users must be more aware on how to build models to represent a decision or process. Training courses are under development to assist both the basic user and the more advanced user on how to fully utilize the produ
26.0	**21.4**	**36.3**	**23.4**	**Average**
12.8	**15.8**	**4.8**	**7.4**	**Standard Deviation**

Question 6

When designing your product, how important is it to your users that the program support the following DSS considerations

6.a Modeling uncertainty	6.b Subjectivity	6.c Utility functions	6.d Risk	6.e Sensitivity analysis	6.f f. Availability of math functions	6.g
35	5	15	0	45	0	
10	15	15	10	25	25	
20	12	12	20	36	0	Influence diagrams, probabilistic analysis, multiattribute utility models
15	25	20	10	25	5	I think its important to be able to recreate the "audit trail" that leads to any particular utility, so the math functions are important. However, this should be very easy unless the software uses a proprietary method. Thus, I don't think retrieving the formulas is
15	25	18	19	18	5	Time series analysis, simpler, faster weighting methods (such as ROC) for less sophisticated rough decisions, Optimization for a knapsack, group analysis features, risk aversion utilities, guiding wizards and support within the software. Levels of sop sophistication within the software to accommodate different levels of understanding and expertise.
19.0	**16.4**	**16.0**	**11.8**	**29.8**	**7.0**	**Average**
9.6	**8.6**	**3.1**	**8.1**	**10.7**	**10.4**	**Standard Deviation**

Question 7

Support. How important are the following support related issues to your users.

7.a FAQ file online	7.b Discussion group availability	7.c Mail lists availability	7.d Technical support via phone or email	7.e Level of local support available	7.f Is there online documentation	7.g
10	10	0	50	5	25	
5	15	5	30	15	30	
15	15	5	30	5	25	
20	17	17	27	17	3	High quality paper documentation and examples
10	20	5	40	5	50	Direct dial in to web site for updates and automated fix procedures. Personal service, listening to user suggestions, complaints, and queries to improve product. Supporting training organizations and programs.
12.0	**15.4**	**6.4**	**35.4**	**9.4**	**26.6**	**Average**
5.7	**3.6**	**6.3**	**9.5**	**6.1**	**16.7**	**Standard Deviation**

Question 8

Please take a moment and think about other considerations when designing DSS software. Are there any other issues you would like to share

Support for collaborative model development and decision making
The target market of the software must be well considered before design. Open architecture features are necessary for larger market capability. Proper training and support services must grow and be prepared for growth. Ease of learning and user interface should comply to user interface standards. Remove the "black box" characteristics of decision making, even at the expense sometimes of technical complexity, at least for novices. A product not used is a dead product.

APPENDIX H - SURVEY RESPONSES - PRODUCTION

Question 1:

a. Which DSS packages have you used before in the classroom? With regards to the questions shown below, what features attracted you to the packages you used?

b. Which DSS packages have you rejected for use in the classroom? Why?

1.a	1.b
Decision Maker (DOS and Windows versions) and DATA. DDE capabilities for Internet applications, attractive interface, good print options for publications attracted me to DATA.	Smltree, simply because I felt that Smltree was similar to DM
Crystal Ball for the Mac and PC. This software is a macro add-in to Excel and is very useful for Monte Carlo simulation for small-medium problems that lend themselves to spreadsheet analyses. The resulting files are cross platform compatible and, hence, are usable to PC/Mac users; additionally many customer organizations are familiar with Excel and, therefore, more willing to "trust" the results. TreeAge DATA graphical event trees which are useful for "visualizing" the problem	

Question 2:

What do you see as the primary intended purpose of DSS software

2.a	2.b	
Production (Strategic use	Production (lower level use	
70	30	
50	50	
50	50	
50	50	
25	75	
50	50	
42	**58**	**Average**
14	**14**	**Standard Deviation**

Question 3

Software selection. When selecting software, how important do you feel the following issues are

3.a	3.b	3.c	3.d	3.e	3. f	3.g
Length of time to required to learn	Ease of use	Multiple platform support	Ability to use on network	Cost of acquiring package	Power	
10	10	5	5	10	60	
30	20	0	10	20	20	
15	30	10	10	15	20	
10	15	10	5	20	40	Among the other criteria I use to evaluate a DSS I need to know about the algoritm and how the programme works ...is it a black box?
25	25	10	5	5	30	Compatibility with customer platform(s) and sufficiently "user friendly" to the customer.
10	25	40	0	0	25	Interoperatilty with other tools... RDBMS, CASE.
25	25	0	10	10	30	
17	**24**	**14**	**6**	**10**	**29**	**Average**
8	**5**	**15**	**4**	**8**	**7**	**Standard Deviation**

Question 4

Application related questions. Which available features do you feel are most important

4.a	4.b	4.c	4.d	4.e	4.f	4.g	4.h	4.I	4.j	4.k
Mouse and windows support	Input characteristics	Output representation	DBMS functions	Version management	Data import and export capability	Ability to build large, complex models	Model version support	Model export to other applications	Availability of statistical functions	
10	10	10	15	5	5	30	5	5	5	Output representation for trees is very important for publications
10	10	10	10	10	10	10	10	10	10	
13	10	10	8	10	17	7	4	20	4	Relevance to the intended user
15	0	15	0	0	10	10	5	20	25	
20	5	20	10	15	15	0	15	0	0	
3	10	20	2	2	3	30	10	10	10	
13	**6**	**16**	**5**	**7**	**11**	**12**	**9**	**13**	**10**	**Average**
7	**5**	**5**	**5**	**7**	**6**	**13**	**5**	**10**	**11**	**Standard Deviation**

Question 5

Training related issues. Which of the following features related to using the program are important

5.a	5.b	5.c	5.d	
Sample exercises are provided	Computer based tutorials are provided	Results are explained	The program provides tips and insight	
20	30	20	30	
10	10	60	20	
20	30	30	20	
20	20	40	20	
20	20	20	40	
25	10	40	25	
40	10	25	25	
25	**18**	**31**	**26**	**Average**
9	**8**	**9**	**8**	**Standard Deviation**

Question 6:

How important is it that the program support the following considerations

6.a	6.b	6.c	6.d	6.e	6.f	6.g
Modeling uncertainty	Subjectivity	Utility functions	Risk	Sensitivity analysis	Availability of math functions	
20	15	30	10	15	10	
25	25	5	20	15	10	
18	18	18	18	18	18	
20	0	0	25	25	30	
						The variance between one application and another is too high to reasonably address this question. It depends on the problem at hand
40	10	5	5	40	0	
26	**9**	**8**	**16**	**28**	**16**	**Average**
12	**9**	**9**	**10**	**11**	**15**	**Standard Deviation**

Question 7:

Support. How important are the following support related issues

7.a	7.b	7.c	7.d	7.e	7.f	7.g
FAQ file online	Discussion group availability	Mail lists availability	Technical support via phone or email	Level of local support available	Is there online documentation	
15	10	10	50	5	10	explaining error messages at point of error
15	15	10	30	20	10	
15	5	0	55	10	15	
5	10	15	30	20	20	
25	0	15	25	0	35	
						The custom DSS I was involved in were pre-NET, thus FAQ, Maillist, and discussion groups were N/A
10	10	0	50	10	20	
14	**6**	**8**	**40**	**10**	**23**	**Average**
9	**5**	**9**	**15**	**8**	**9**	**Standard Deviation**

APPENDIX I - COMPARISON OF USER CONSIDERATIONS

	3.a	3.b	3.c	3.d	3.e	3. f
	Length of time to required to learn	Ease of use	Multiple platform support	Ability to use on network	Cost of acquiring package	Power
Education	27	28	3	10	29	
Business	17	24	14	6	10	29
Design	19	31	7	10	9	32
Average	**21**	**28**	**8**	**9**	**16**	**31**
Average Deviation	**3.8**	**2.4**	3.9	**2.0**	8.4	**1.5**

	4.a	4.b	4.c	4.d	4.e	4.f	4.g	4.h	4.i	4.j
	Mouse and windows support	Input characteristics	Output representation	DBMS functions	Version management	Data import and export capability	Ability to build large, complex models	Model version support	Model export to other applications	Availability of statistical functions
Education	17	6	13	11	3	7	12	3	11	16
Production	13	6	16	5	7	11	12	9	13	10
Design	18	8	16	6	4	12	13	7	10	10
Average	**16**	**7**	**15**	**7**	**5**	**10**	**12**	**6**	**11**	**12**
Avg Dev	**2.1**	**1.0**	**1.2**	**2.5**	**1.5**	**2.2**	**0.3**	**2.2**	**1.0**	**2.7**

	5.a	5.b	5.c	5.d
	Sample exercises are provided	Computer based tutorials are provided	Results are explained	The program provides tips and insight
Education	25	32	20	17
Production	25	18	31	26
Design	26	21	36	23
Average	**25**	**24**	**29**	**22**
Average Deviation	**0.4**	5.5	5.9	**3.3**

	6.a	6.b	6.c	6.d	6.e	6.f
	Modeling uncertainty	Subjectivity	Utility functions	Risk	Sensitivity analysis	f. Availability of math functions
Education	23	16	15	15	29	
Production	26	9	8	16	28	16
Design	19	16	16	12	30	7
Average	**23**	**14**	**13**	**14**	**29**	**12**
Average Deviation	**2.5**	3.1	3.5	**1.7**	**0.9**	4.5

	7.a	7.b	7.c	7.d	7.e	7.f
	FAQ file online	Discussion group availability	Mail lists availability	Technical support via phone or email	Level of local support available	Is there online documentation
Education	17	14	10	20	20	20
Production	14	6	8	40	10	23
Design	12	15	6	35	9	27
Average	**14**	**12**	**8**	**32**	**13**	**23**
Average Deviation	**1.8**	**3.8**	**1.4**	7.7	**4.4**	**2.3**

INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center 2
   8725 John J. Kingman Road, Ste 0944
   Ft. Belvoir, Virginia 22060-6218

2. Library 2
   Naval Postgraduate School
   411 Dyer Rd.
   Monterey, California 93943-5101

3. Professor Hemant Bhargava, Code SM/HB 2
   Naval Postgraduate School
   Monterey, California 93943-5101

4. Professor Suresh Sridhar, Code SM/SS 2
   Naval Postgraduate School
   Monterey, California 93943-5101

5. Mr. David Hoffer 1
   TreeAge Software
   1075 Main Street
   Williamstown, Massachusetts 01267

6. CAPT James Garban 1
   Executive Officer
   Fleet and Industrial Supply Center
   937 North Harbor Drive
   San Diego, California 92132

7. LCDR Craig Herrick 4
   12017 Tivoli Park Row #7
   San Diego, California 92128